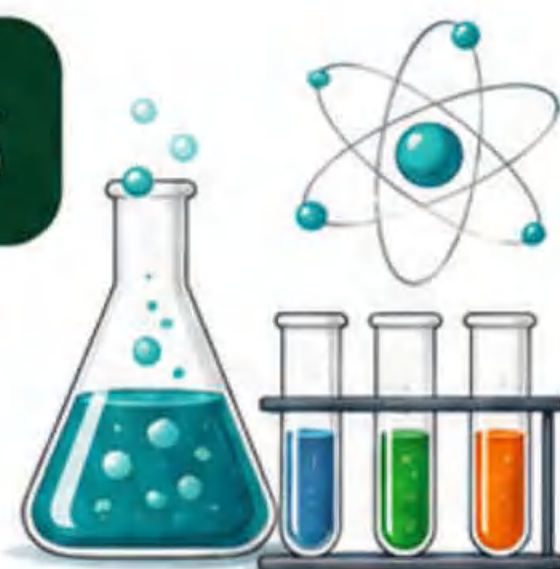




Lesson 1: Types of Chemical Reactions

Unit 1: Chemical Reactions and Their Environmental Effects



1) Learning Objectives

- ✓ Identify the main types of chemical reactions.
- ✓ Compare how metals react with water, acids, and oxygen.
- ✓ Infer the arrangement of metals according to their chemical activity.
- ✓ Use the chemical activity series to predict whether some chemical reactions will occur.
- ✓ Distinguish between single replacement and double replacement reactions through examples.
- ✓ Recognize oxidation, reduction, oxidizing agent, and reducing agent in terms of electron transfer.



2) Key Terms

- Chemical Reaction
- Chemical Reactivity Series
- Single Replacement Reaction
- Double Replacement Reactions
- Neutralization Reactions
- Combustion Reactions
- Redox Reactions
- Oxidizing Agent
- Reducing Agent



3) Skills, Values, and Cross-Cutting Concepts



Skills:

Observation,
Modelling,
Measurement.



Values:

Curiosity,
Rational Use of
Materials.



Issue:

The effect of
metal corrosion
on the economy.



Cross-Cutting Concepts:

Cause and Effect,
Patterns.



4) Warm-Up Inquiry

Dilute hydrochloric
acid added to
marble



Effervescence
is observed

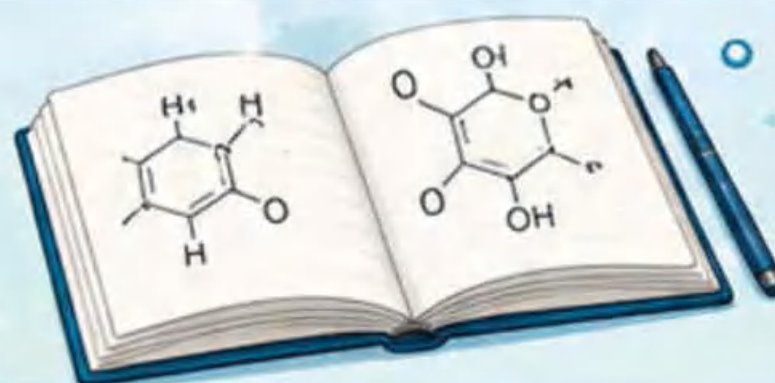
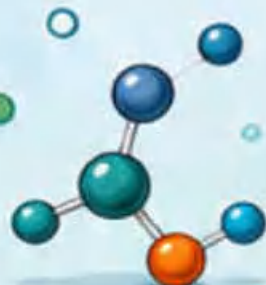
Dilute hydrochloric
acid added to
zinc



Effervescence
is observed

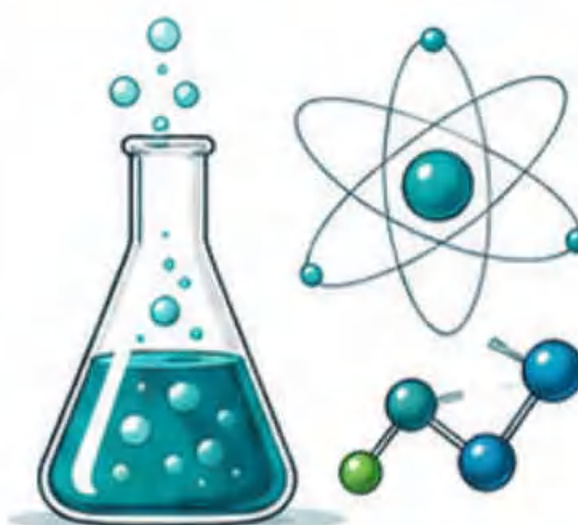
The figure shows two experiments in which obvious effervescence occurs. In one experiment, dilute hydrochloric acid is added to a piece of marble, and in the other it is added to zinc. This lesson explores ideas that help answer the following questions:

- ? Does what we observe mean that the two reactions are the same?
- ? Is the gas released in both experiments the same gas?
- ? Do the two reactions occur in the same way, and do they belong to the same type?
- ? Does every reaction of dilute hydrochloric acid produce a gas?



What Is a Chemical Reaction?

Main Types of Chemical Reactions



1) Definition



A chemical reaction is a process in which bonds in the molecules of the reactants are broken and new bonds are formed in the molecules of the products.

As a result, new substances with different properties are produced.



2) Signs of a Chemical Reaction



✓ Change in color or odor



✓ Evolution of a gas



✓ Formation of a precipitate



✓ Emission of light and heat

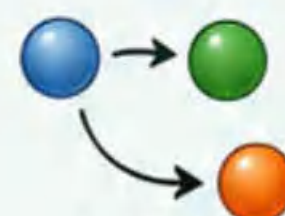
3) Chemical Reactions Can Be Classified Into



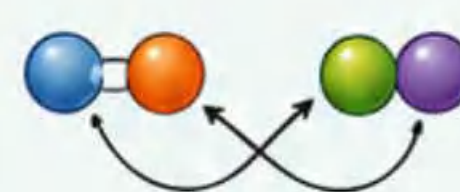
Direct
Combination
Reactions



Decomposition
Reactions



Single
Replacement
Reactions



Double
Replacement
Reactions



4) Type 1: Direct Combination Reactions

These are reactions in which two or more substances combine to form one new compound.

Particle Representation



Symbolic Form



Classifying reactions helps us understand how reactions occur and predict the products of other chemical reactions.





Direct Combination and Decomposition Reactions



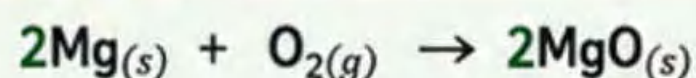
A. Direct Combination Reactions: Metals with Oxygen

1 Magnesium

Magnesium burns quickly with a bright white flame and produces a white substance, magnesium oxide (MgO).



Equation:



2 Iron wool

Iron wool burns in a Bunsen flame producing clear sparks and mainly forms magnetite, iron oxide (Fe_3O_4).



Equation:

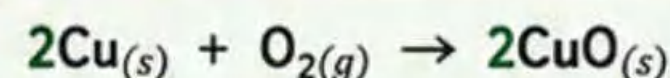


3 Copper

Copper does not burn with a visible flame, but a black layer of copper oxide (CuO) forms on its surface.



Equation:



SAFETY NOTE

Do not look at burning magnesium for a long time. Its intense light and ultraviolet rays may harm the retina, so safety goggles should be worn.



CONCLUSION

Most metals combine with oxygen when heated in air, but they differ in chemical activity. Magnesium is more active than iron, and iron is more active than copper.

B. Decomposition Reactions



DEFINITION:

These are reactions in which some compounds break down into simpler substances by using a form of energy such as heat or light.

AB



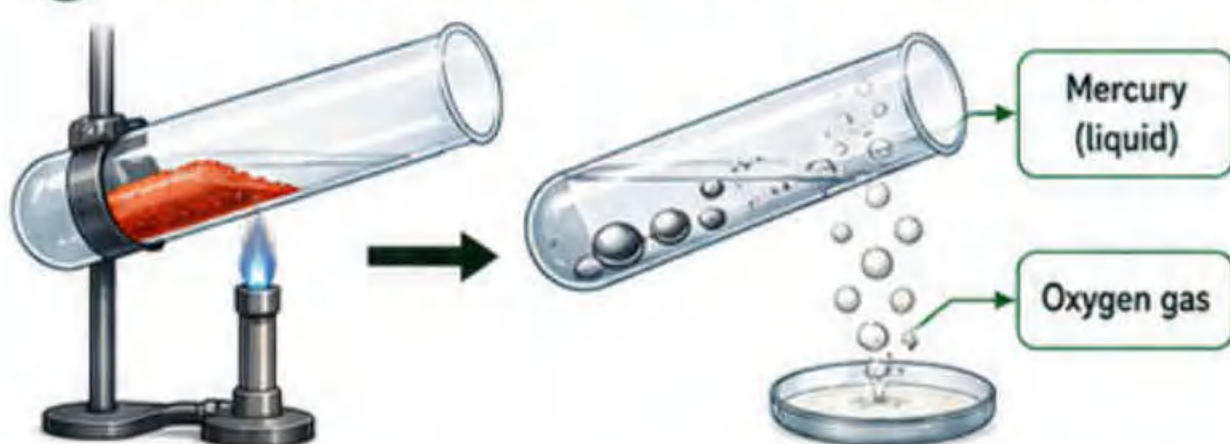
→

A

+

B

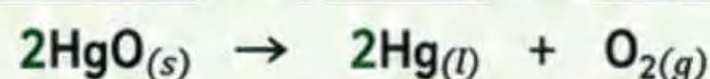
1 Decomposition of red mercury oxide on heating



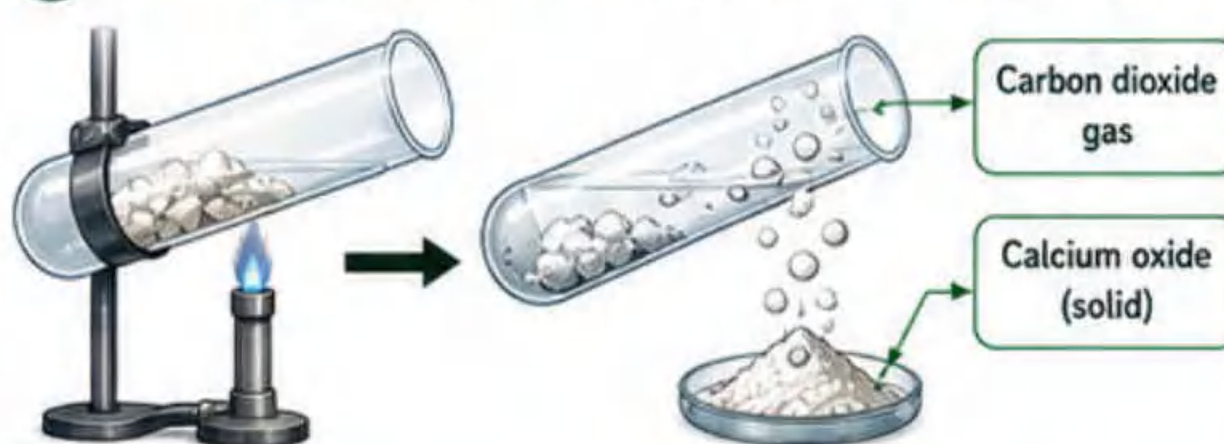
Mercury
(liquid)

Oxygen gas

Equation:



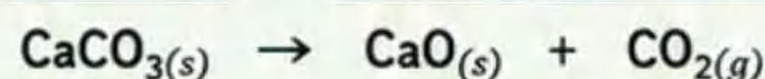
2 Decomposition of calcium carbonate on heating



Carbon dioxide
gas

Calcium oxide
(solid)

Equation:



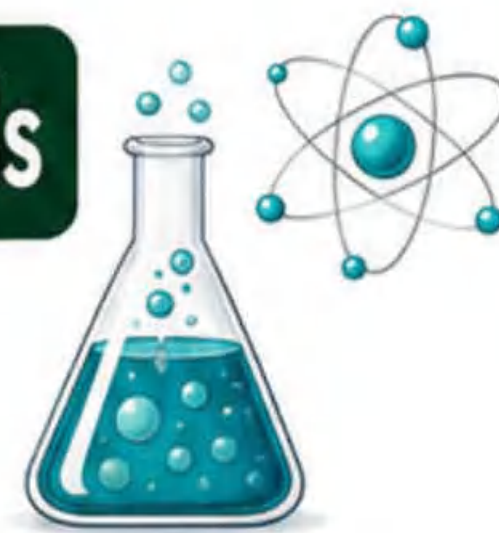
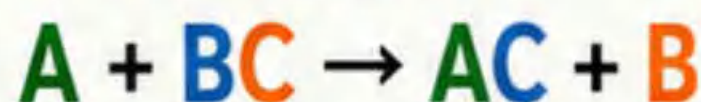


Single Replacement Reactions: Metals with Acids



Single replacement reactions are reactions in which one element replaces another element in a compound.

General form:



Case 1: A Metal Replaces Hydrogen in an Acid



Activity 1: Reaction of Magnesium with Dilute Hydrochloric Acid



Aim:

To observe the reaction of magnesium with dilute hydrochloric acid.



Tools:

test tube, magnesium strip (Mg), dilute hydrochloric acid (HCl), burning splint.



Steps:

1. Place the magnesium strip in a test tube.
2. Add about 2 mL of dilute hydrochloric acid.
3. Cover the mouth of the test tube briefly.
4. Bring a lighted splint near the mouth carefully.



Observation:

Rapid vigorous reaction and gas bubbles form; the gas burns with a popping sound.

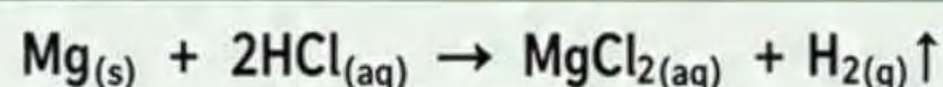


Conclusion:

Magnesium reacts chemically with dilute hydrochloric acid to form magnesium chloride, and hydrogen gas is released.



Equation:



Activity 2: Comparing Zinc, Iron, and Copper with Dilute Hydrochloric Acid

Zinc (Zn)



Many bubbles, fast reaction

Iron (Fe)



Fewer bubbles, slower reaction

Copper (Cu)



No visible bubbles, no reaction

Observation Summary

Metal	Reaction with Dilute HCl	Bubble Formation	Reaction Rate
Zinc (Zn)	Reacts	Many bubbles	Fast
Iron (Fe)	Reacts	Fewer bubbles	Slow
Copper (Cu)	Does not react	No visible bubbles	No reaction

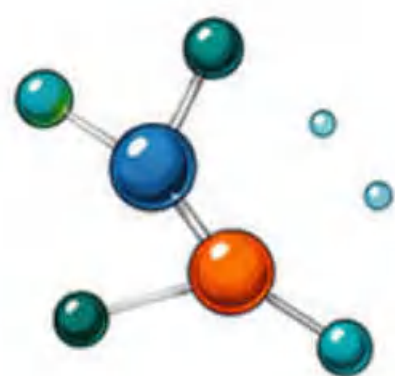


Setup: Equal masses of zinc, iron, and copper are added separately to equal volumes of dilute hydrochloric acid.

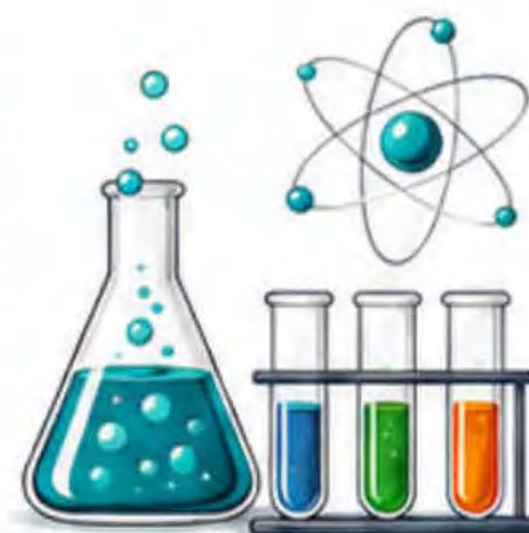


Metals differ in chemical activity. This difference appears in how fast they react with dilute acids. This leads to the chemical activity series.





Chemical Activity Series



↑
More Active Metals

1	Potassium	K
2	Sodium	Na
3	Lithium	Li
4	Barium	Ba
5	Calcium	Ca
6	Magnesium	Mg
7	Aluminum	Al
8	Zinc	Zn
9	Iron	Fe
10	Tin	Sn
11	Lead	Pb
12	Hydrogen	H
13	Copper	Cu
14	Mercury	Hg
15	Silver	Ag
16	Platinum	Pt
17	Gold	Au

Hydrogen Reference →

↓
Less Active Metals / Inactive Elements



1) What Is the Chemical Activity Series?

It is an arrangement of metallic elements in decreasing order according to their chemical activity.



2) Rule with Dilute Acids

Metals that come before hydrogen in the series can replace hydrogen from dilute acids.

Metals that come after hydrogen do not react with dilute acids and cannot replace hydrogen from the acid.



3) Additional Note

Aluminum does not react immediately with dilute hydrochloric acid because a layer of aluminum oxide (Al_2O_3) covers its surface and acts as a barrier. After some time, this layer is removed and bubbles of hydrogen gas begin to appear.



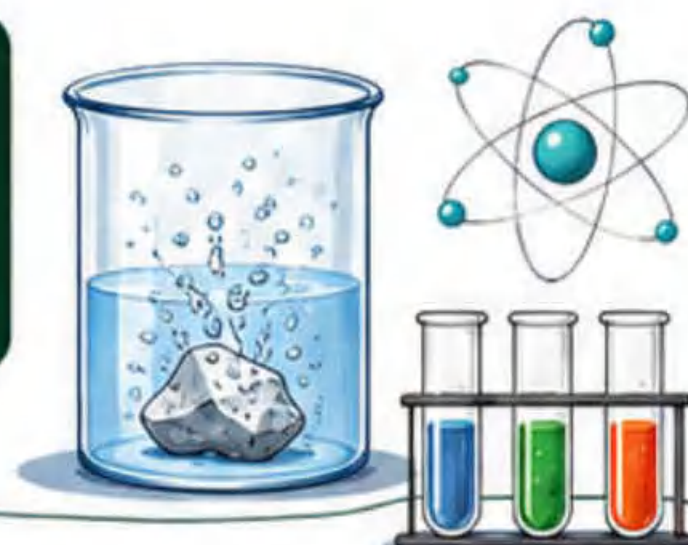
This series helps us predict which reactions can occur.

A more active metal can replace a less active metal from its compounds in solution or from other substances.





Single Replacement Reactions: Metals with Water and Salt Solutions



A A Metal Replaces Hydrogen in Water



Aim: To observe the reaction of sodium with water.



Tools: water, glass dish, a very small piece of sodium metal, forceps, filter paper.



Observations:

- Sodium floats on the surface because its density is less than that of water.
- The sodium piece moves quickly on the surface because it reacts immediately and vigorously with water.



Conclusion:

Sodium replaces the hydrogen of water to form sodium hydroxide solution, and hydrogen gas is released; the gas can ignite with a popping sound.



1
A very small piece of sodium is placed on the surface of water.



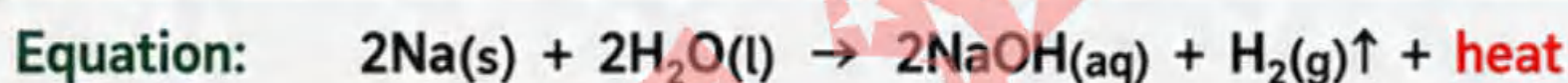
2
The sodium floats and moves quickly on the surface.



3
Bubbles of gas are released, and heat is produced.



4
The hydrogen gas ignites with a popping sound.



A large amount of heat is produced when sodium reacts with water. Water must not be used to extinguish a sodium fire; dry sand should be prepared for emergency use.

B Magnesium with Cold and Hot Water

Cold Water



Observation:

Magnesium shows no clear reaction with cold water.

Hot Water



Observation:

Magnesium reacts with hot water.



Conclusion:

Magnesium is less chemically active than sodium and needs heat energy to begin reacting with water.



C A More Active Metal Replaces a Less Active Metal from Its Salt Solution

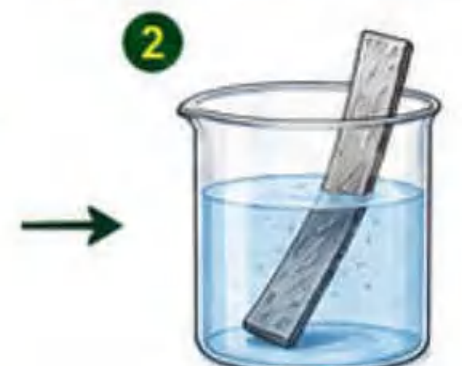


Example:

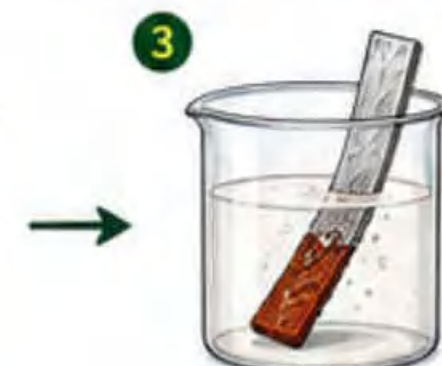
Zinc in blue copper sulfate solution.



1
Zinc is placed in blue copper sulfate solution.



2
The blue color of the solution gradually disappears.

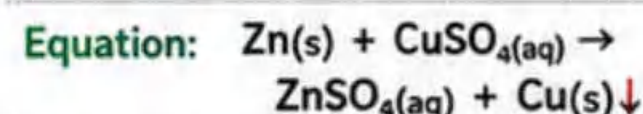


3
Red copper is deposited on the zinc strip.



Observation:

The blue color of the copper sulfate solution gradually disappears and red copper is deposited.



Conclusion:

According to the chemical activity series, a metal that comes earlier in the series can replace a metal that comes later from its salt solution.



Application:

Silver tools that lose their shine can be restored in hot water containing sodium bicarbonate and a piece of aluminum foil, because aluminum is more active than silver and replaces it during the reaction.





Double Replacement Reactions: Neutralization



A double replacement reaction is a reaction between two ionic compounds, usually in aqueous solution, in which cations and anions exchange places to form two new compounds.



What Is an Ionic Compound?

An ionic compound such as sodium chloride (NaCl) is made of two parts: a positive ion called a cation, such as sodium ion (Na⁺), and a negative ion called an anion, such as chloride ion (Cl⁻).



Reaction Type 1: Acid + Alkali (Neutralization Reaction)

Tools



Test tube



Dilute sodium hydroxide solution (NaOH)



Dilute hydrochloric acid (HCl)



Universal indicator

Universal Indicator Color Strip



Step	Action	Observation
1	Place about 1 mL of dilute sodium hydroxide solution in the test tube.	The solution is colorless.
2	Add a few drops of universal indicator.	The sodium hydroxide solution is a strong colorless alkali and usually becomes violet or purple after adding the universal indicator.
3	Add dilute hydrochloric acid gradually to the solution.	The color changes gradually to green; this is the neutral point.
4	Add more hydrochloric acid gradually.	With more hydrochloric acid, the color changes to yellow.
5	Add more hydrochloric acid gradually.	The color changes to orange.
6	Add more hydrochloric acid gradually.	The color may become red with even more acid.



The reaction of dilute hydrochloric acid with sodium hydroxide solution is a double replacement reaction. It produces sodium chloride (a salt) and water, so it is called a **neutralization reaction**.

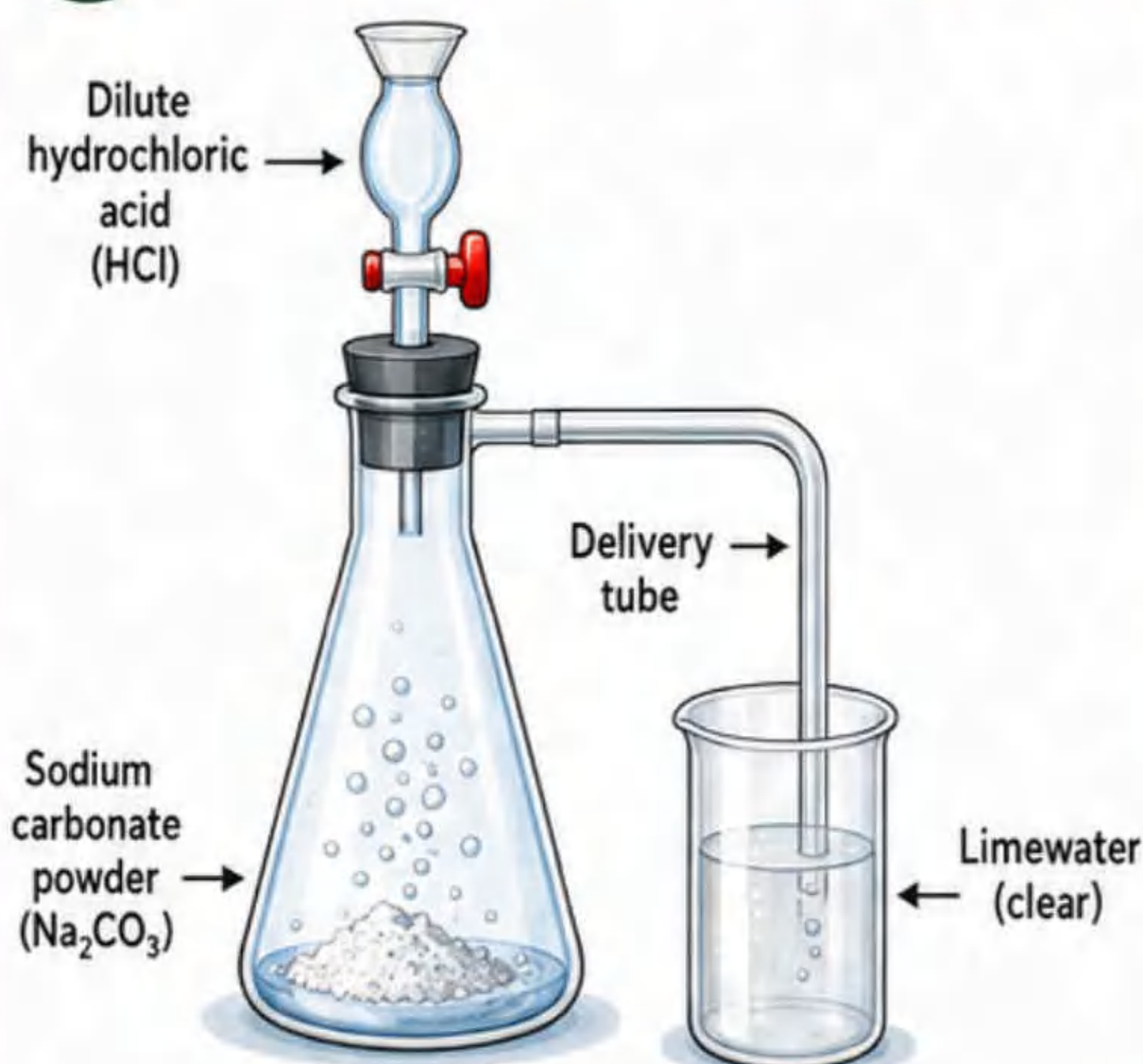




Double Replacement Reactions: Other Important Cases



1) Strong Acid + Salt of a Weak Acid



Experiment: Dilute hydrochloric acid is added to sodium carbonate powder in a conical flask. The gas produced is passed through a delivery tube into limewater.



Observation: Effervescence occurs in the flask, and the gas passed into limewater turns it milky.



Conclusion: Hydrochloric acid reacts with sodium carbonate in a double replacement reaction to form sodium chloride and carbonic acid. The carbonic acid then breaks down into water and carbon dioxide.



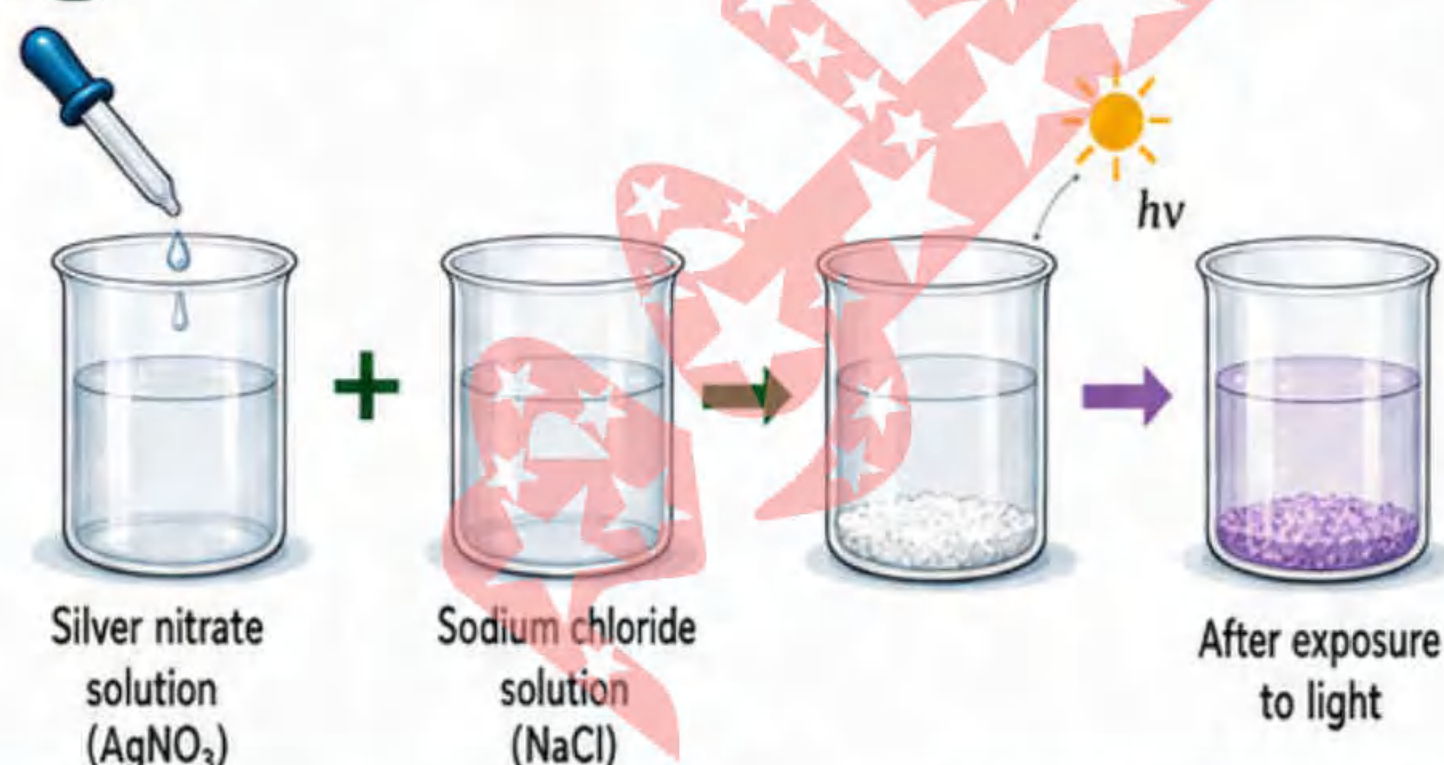
Equation:



A strong acid ionizes almost completely in water, while a weak acid ionizes only partially.



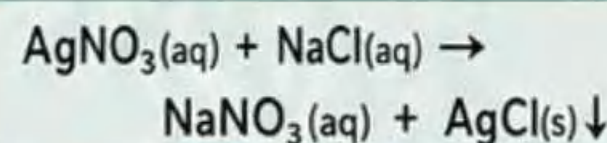
2) Precipitation Reaction (Between Two Salt Solutions)



Observation: A white precipitate of silver chloride forms, and after exposure to light it turns violet.



Equation:



Conclusion: This is a double replacement reaction that produces an insoluble precipitate.



Application: Treating Hard Water

Some groundwater contains high proportions of calcium and magnesium salts. This is called hard water. It causes solid scale deposits inside water pipes and heaters. Water can be treated with sodium carbonate so precipitation reactions convert some dissolved salts into insoluble solids that are easier to remove.





Redox Reactions



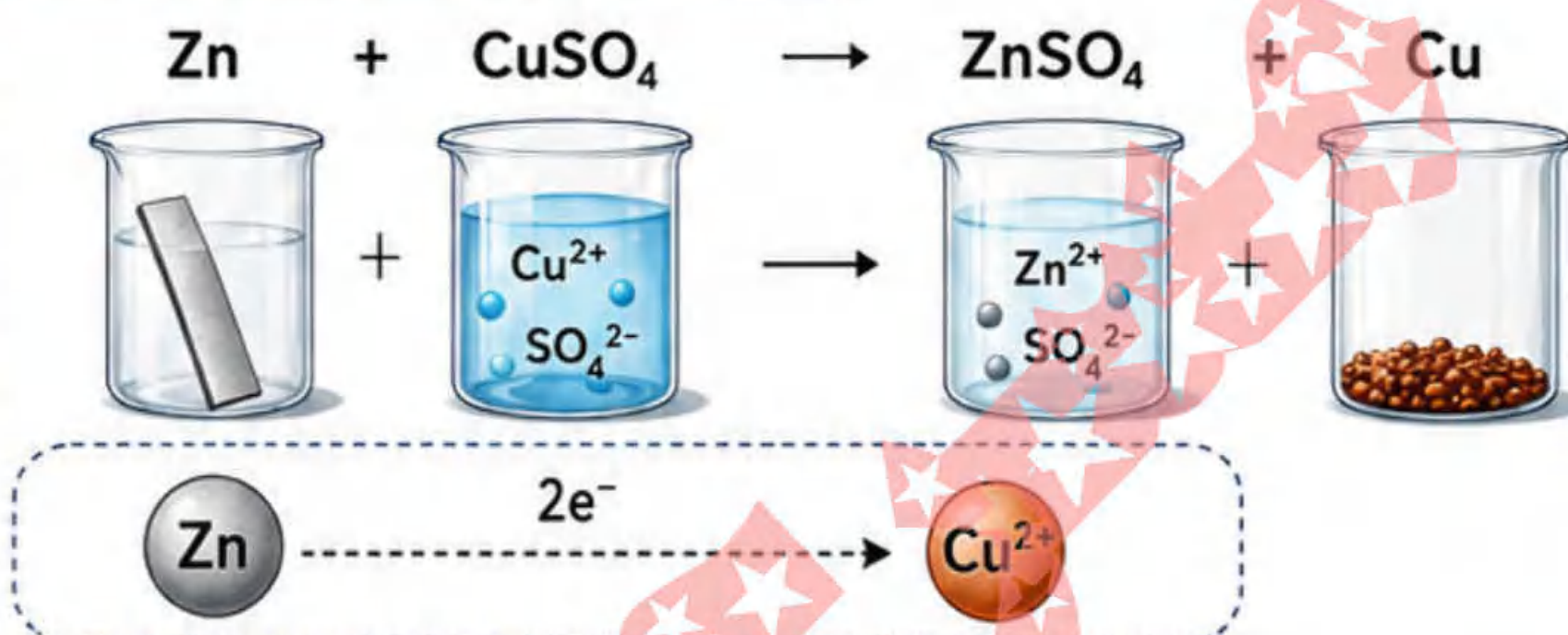
Oxidation was first learned as a chemical process that increases the oxygen content of a substance or decreases its hydrogen content, while reduction decreases the oxygen content or increases the hydrogen content. Some chemical reactions involve oxidation and reduction without depending directly on oxygen or hydrogen proportions in the reactants.



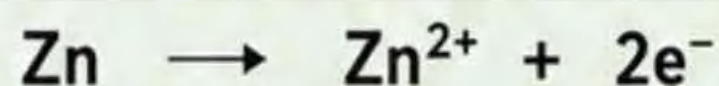
1) Main Example: Zinc with Copper Sulfate Solution

Before reaction:

Zinc is made of electrically neutral atoms, while copper in the solution exists as positive ions (Cu^{2+}).

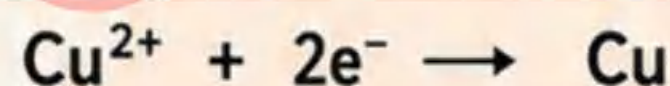


Zn 2) Oxidation Half-Reaction



During the reaction, the zinc atom loses two electrons and becomes a positive zinc ion (Zn^{2+}). This loss of electrons is called **oxidation**, and zinc is the **reducing agent**.

Cu2+ 3) Reduction Half-Reaction



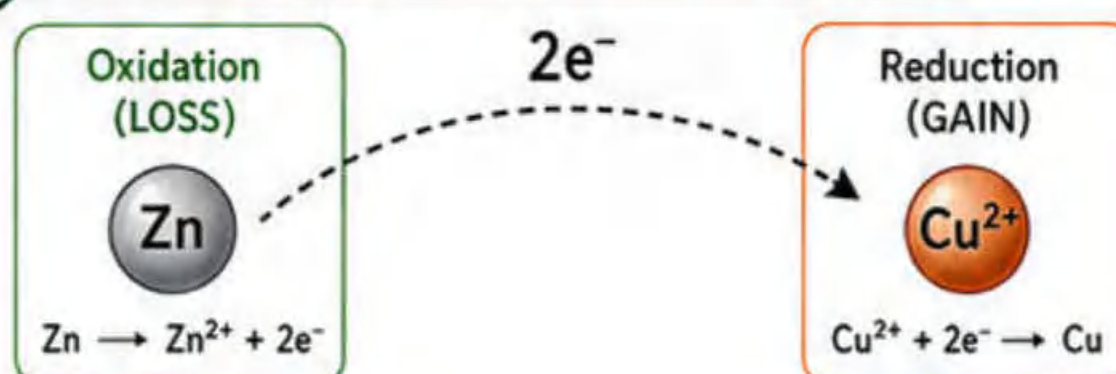
The positive copper ion gains these two electrons and becomes a neutral copper atom. This gain of electrons is called **reduction**, and copper sulfate is the **oxidizing agent**.

4) Summary Definitions

- ✓ **Oxidation:** a chemical process in which an atom or ion loses one or more electrons.
- ✓ **Reduction:** a chemical process in which an atom or ion gains one or more electrons.
- ✓ **Oxidizing agent:** the substance that gains one or more electrons during the chemical reaction.
- ✓ **Reducing agent:** the substance that loses one or more electrons during the chemical reaction.



5) Electron Transfer: The Concept



Oxidation and reduction are inseparable processes; they always occur together.

? 6) Check Your Understanding



- 1 Which substance is oxidized?
- 2 Which substance is reduced?
- 3 Which substance acts as the oxidizing agent?
- 4 Which substance acts as the reducing agent?





Combustion Reactions and Environmental Pollution



Unit 1: Chemical Reactions and Their Environmental Effects

1 LESSON VOCABULARY



Combustion



Complete Combustion



Incomplete Combustion



Flammability



Ignition Point



Soot

2 LEARNING OBJECTIVES

By the end of this lesson, students should be able to:

- 1 Explain scientifically why some materials are flammable.
- 2 Compare the products of complete and incomplete combustion for some materials.
- 3 Infer the properties of combustion products and their effects on the environment.
- 4 Design solutions to reduce pollution caused by combustion reactions.

3 THINK ABOUT IT

- 1 Why do tree leaves catch fire easily, while a tree branch takes a longer time to burn?
- 2 How does forest burning affect the atmosphere?
- 3 How can we protect the environment from pollution caused by combustion?

4 SKILLS, VALUES, AND CROSSCUTTING CONCEPTS



Process Skills: Communication; evaluating sources and reliability.



Value: Protecting the environment.



Issue: The future of energy.



Crosscutting Concepts: Stability and change; cause and effect.

5 LESSON PREVIEW



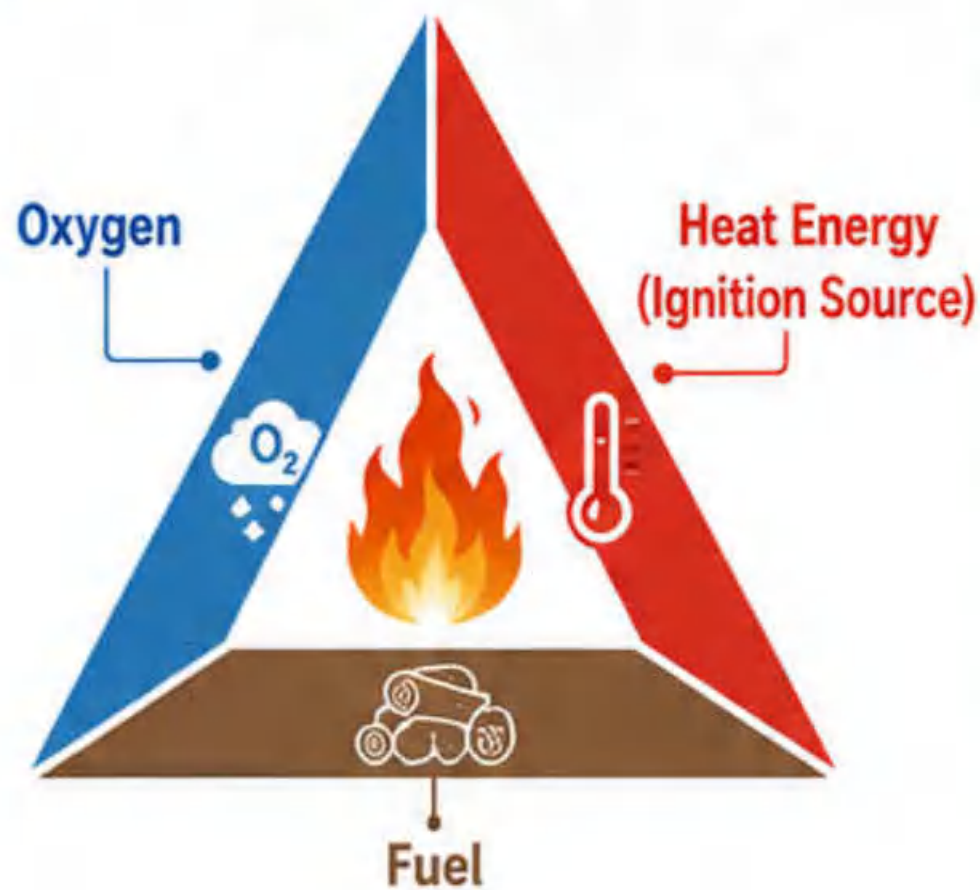


Conditions for Combustion



Ignition Point and Flammability

1 FIRE TRIANGLE



Combustion happens only when the three elements of the fire triangle are present.

? What happens if one element is missing?

2 ACTIVITY 1 – INVESTIGATE AND CONCLUDE

Activity 1: Ignition Point and Flammability

Aim: To investigate how a substance reaches its ignition point.

Tools: Water, two small paper cups, two candles, two tripod stands.

Steps:

- 1 Pour water into one cup and leave the other cup empty.
- 2 Place each cup on a stand.
- 3 Light a candle under each cup.



Observation: The empty cup starts to burn faster than the cup containing water.

Conclusion: Combustion does not begin until a substance reaches its ignition point. The empty cup reaches its ignition point first, while the cup containing water stays below its ignition point because water absorbs heat.



3 IGNITION POINT

The lowest temperature a substance must reach to start burning and continue burning spontaneously.



4 FLAMMABILITY

How easily and how quickly a substance ignites at the surrounding temperature.



5 FLAMMABLE MATERIALS NOTE

Flammable substances such as gasoline and alcohol are classified as flammable materials. Tanks carrying them show warning signs to indicate danger.



FLAMMABLE
KEEP FIRE AWAY
NO SMOKING

6 SAFETY FIRST



Wear protective equipment such as goggles and gloves.



Keep flammable materials away from the flame.



Prepare fire-extinguishing tools for emergencies.





What Is Combustion?

Lighting a Match and Burning Metals



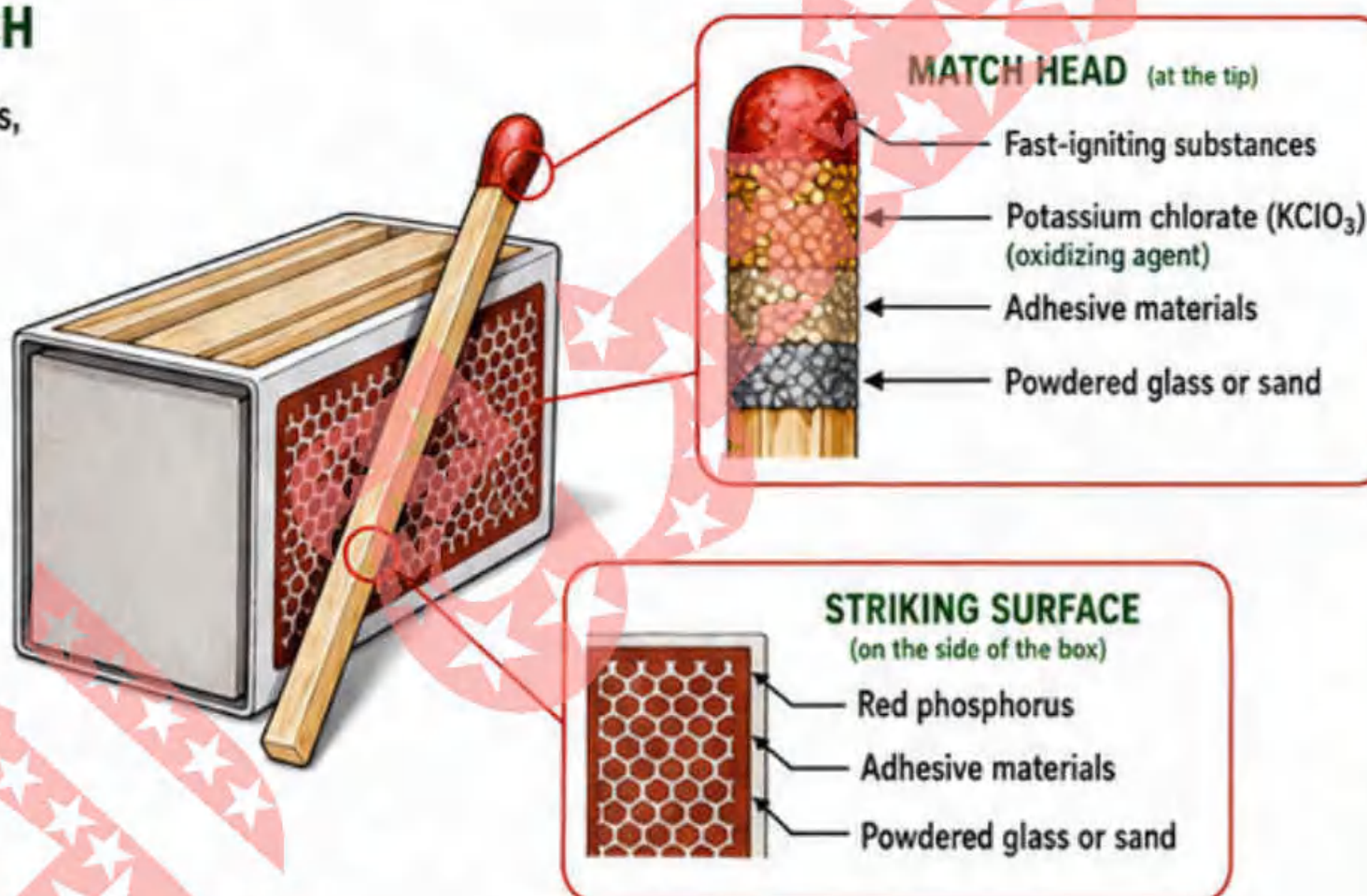
1 DEFINITION OF COMBUSTION



Combustion is a chemical reaction between a substance and oxygen that produces heat, light, or both. New substances are formed, and these products differ according to the material being burned.

2 LIFE APPLICATION – LIGHTING A MATCH

- 1 The head of a match contains several chemical compounds, including an oxidizing agent such as potassium chlorate (KClO_3), fast-igniting substances, adhesive materials, and powdered glass or sand.
- 2 The striking surface on the side of the box contains red phosphorus, adhesive materials, and powdered glass or sand.
- 3 When a match is struck, heat from friction changes a small amount of red phosphorus into white phosphorus.
- 4 White phosphorus ignites spontaneously in air, causing potassium chlorate to decompose and produce potassium chloride (KCl) and oxygen (O_2).
- 5 As a result, the match head and the wood burn more strongly and more quickly.



3 ACTIVITY 2: BURNING METALS

Aim: To observe the combustion of magnesium and compare it with the combustion of carbon.



TOOLS



A piece of charcoal (C)



A cleaned magnesium ribbon (Mg)



A Bunsen flame



Heat-resistant tongs

STEPS

- 1 Hold the magnesium ribbon carefully using the tongs.
- 2 Heat the ribbon in the flame until it burns.
- 3 Repeat the previous steps with the piece of charcoal.

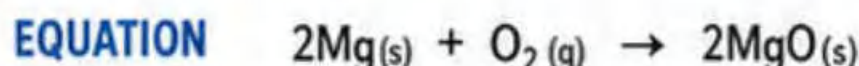


OBSERVATION FOR MAGNESIUM

Magnesium burns with a bright white light and forms a white powder of magnesium oxide.



EQUATION



GENERALIZATION

Most metals burn to form basic metallic oxides. Some of these oxides dissolve in water to form alkaline solutions that turn sunflower indicator blue.

4 SAFETY NOTE



Do not stare for a long time at the bright magnesium flame. Its intense light is accompanied by ultraviolet rays that may damage the retina, so protective goggles must be worn.





Combustion of Nonmetals

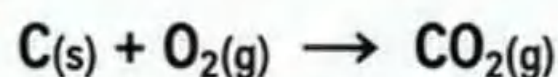


Complete and Incomplete Combustion

1 BURNING CARBON



- Carbon (charcoal) glows and carbon dioxide gas (CO_2) is released.



- Most nonmetals burn to form acidic nonmetal oxides.
- Most of these oxides dissolve in water to form acids that turn sunflower indicator red.

2 ACTIVITY 3 — INVESTIGATE AND CONCLUDE

Activity 3: Complete and Incomplete Combustion in a Bunsen Flame

- Aim:** To compare the blue flame and the yellow flame of a Bunsen burner.

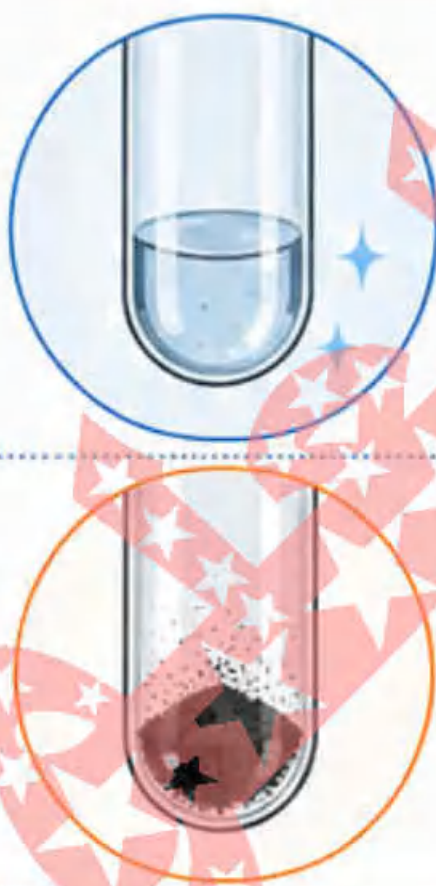
- Tools:** a Bunsen burner, a test tube, some water, a holder.

Steps:

- Put some water into the test tube.
- Light the Bunsen burner with the air hole fully open until the flame becomes blue.
- Hold the test tube in the blue flame for one minute.
- Partly close the air hole until the flame becomes yellow.
- Hold the test tube in the yellow flame for one minute.

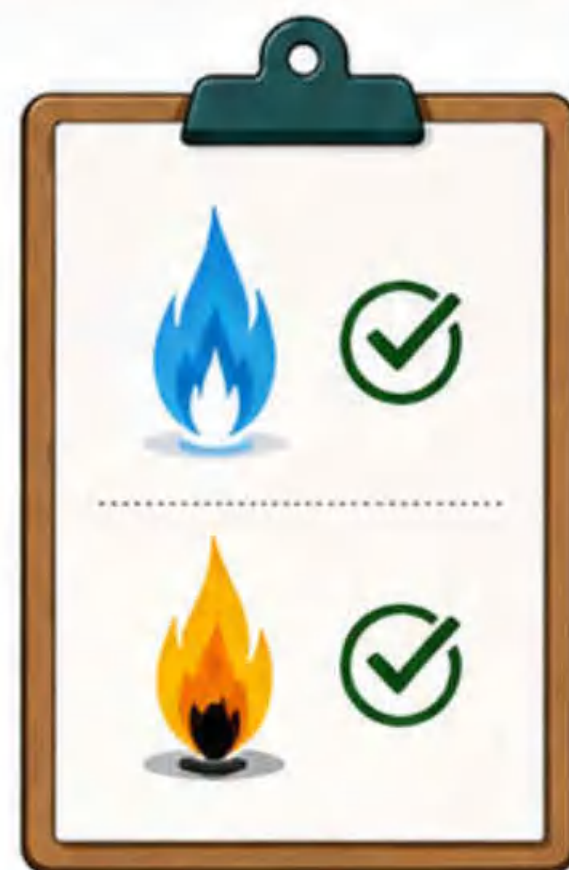
Observation:

- With the blue flame, the bottom of the test tube remains completely clean.
- With the yellow flame, a black powder of unburned carbon forms on the bottom of the test tube.



Conclusion:

- A blue flame appears when more oxygen enters, allowing the gas to burn completely.
- A yellow flame appears when less oxygen is available, so incomplete combustion occurs and soot is formed.



3 COMPARISON: BLUE FLAME vs. YELLOW FLAME

BLUE FLAME (AIR HOLE OPEN)

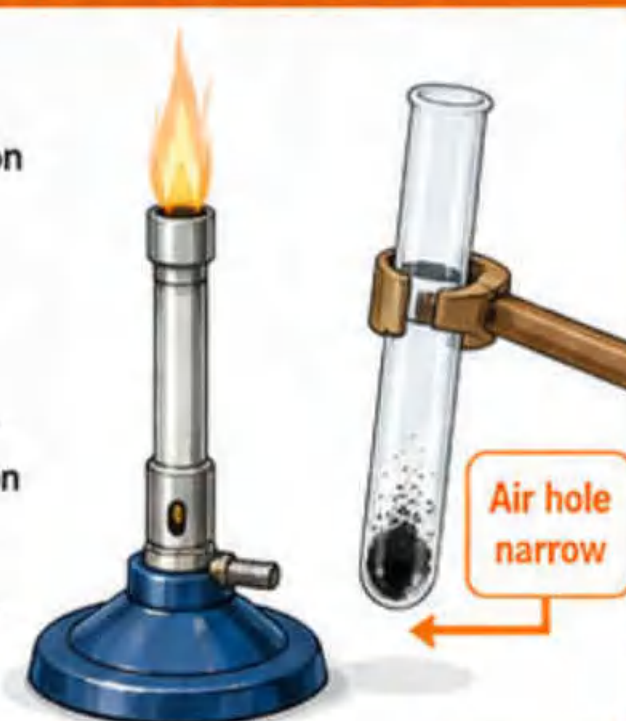


- More oxygen enters.
- Complete combustion occurs.
- Carbon burns completely to form carbon dioxide.
- Clean test tube — no soot forms.

	Air Hole Setting
O_2	Oxygen Supply
	Type of Combustion
	Products
	Result in Test Tube

YELLOW FLAME (AIR HOLE NARROW)

- Less oxygen enters.
- Incomplete combustion occurs.
- Fuel does not burn completely.
- Carbon dioxide, water vapor, and soot (carbon particles) are formed.
- Soot forms in the test tube.



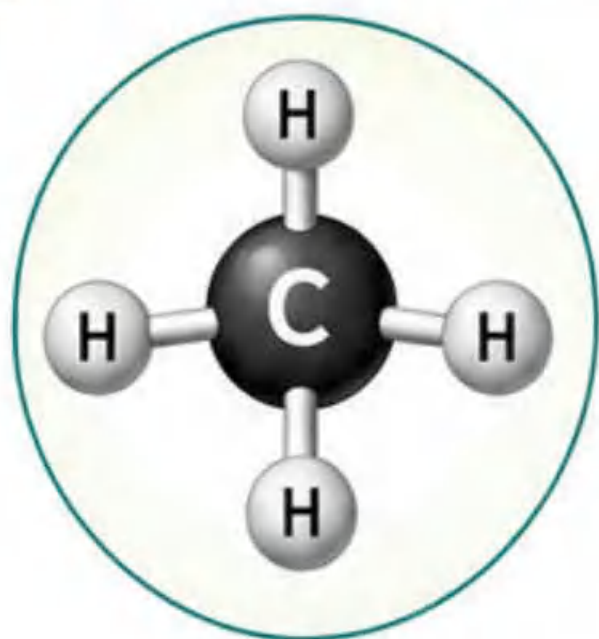


Combustion of Hydrocarbon Gases



Methane: Complete and Incomplete Combustion

1 INTRODUCTORY KNOWLEDGE



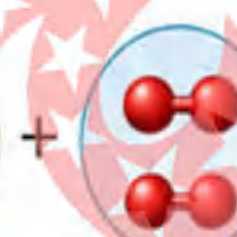
- The gases used in Bunsen burners and home gas stoves belong to a group of chemical compounds called hydrocarbons.
- Hydrocarbons are made mainly of hydrogen and carbon.
- Natural gas is mainly methane.
- Butagas is composed mostly of propane and butane.



2 COMPLETE COMBUSTION OF HYDROCARBONS



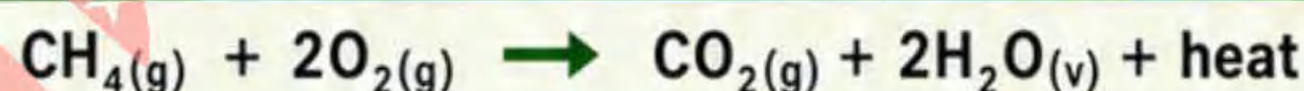
- In the presence of a sufficient amount of oxygen, hydrocarbon gases such as methane burn completely.
- Carbon dioxide gas, water vapor, and a large amount of heat are produced.


 CH_4

 2O_2

 CO_2

 $2\text{H}_2\text{O}$


heat

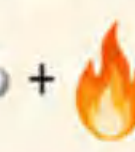
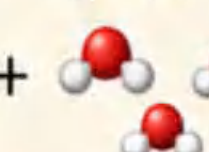
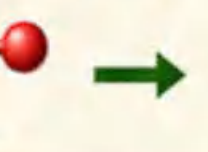
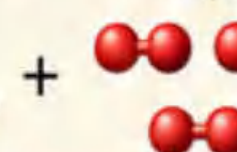


3 INCOMPLETE COMBUSTION OF HYDROCARBONS

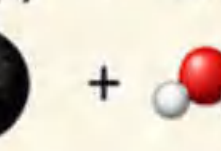
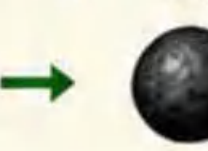
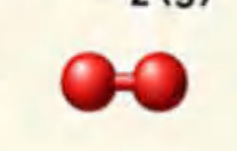
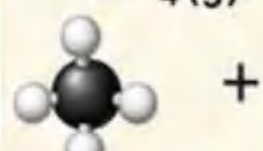
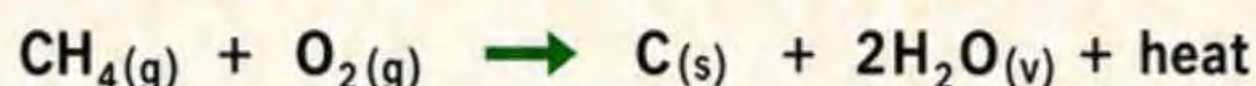


- Incomplete combustion happens when there is not enough oxygen.
- The products depend on the amount of oxygen available for the reaction.
- For methane, incomplete combustion may produce carbon monoxide and water vapor, or carbon (soot) and water vapor.

(a) Incomplete combustion producing carbon monoxide



(b) Incomplete combustion producing carbon (soot)



4



For a given mass of hydrocarbon fuel, incomplete combustion releases less thermal energy than complete combustion of the same mass of fuel.



5 CHECK YOUR UNDERSTANDING



Use the equations to infer the number of oxygen molecules needed to burn two molecules of methane in each reaction.





Flame Colour and Combustion Products



Heating Efficiency and Detecting the Products of Combustion

1 LIFE APPLICATION — FLAME COLOUR AND HEATING EFFICIENCY

BLUE FLAME

Complete Combustion



VS

YELLOW / ORANGE FLAME

Incomplete Combustion



- ✓ The colour of the flame in a home gas burner indicates the type of combustion.
- ✓ A blue flame appears when enough oxygen is available for complete combustion.
- ✓ This produces carbon dioxide, water vapor, and a large amount of heat, which helps food cook faster and uses less gas.

- ✗ A yellow or orange flame appears when oxygen is insufficient, indicating incomplete combustion.
- ✗ This produces poisonous carbon monoxide and black soot that deposits on utensils, and heating efficiency decreases.
- ✗ In this case, the flame openings should be cleaned or the air inlet should be adjusted to ensure safety and efficient use.

2 ACTIVITY 4: DETECTING THE PRODUCTS OF COMBUSTION



Aim:

To identify the products formed when a hydrocarbon gas burns completely.



Tools:

- A test tube containing clear limewater
- A two-branched tube containing pale blue anhydrous cobalt chloride paper
- A funnel
- Connecting tubes
- An ice bath
- A stand
- A Bunsen burner



Steps:

- 1 Use the tools to set up the apparatus as shown.
- 2 Light the Bunsen burner for a short time, for example about two minutes.



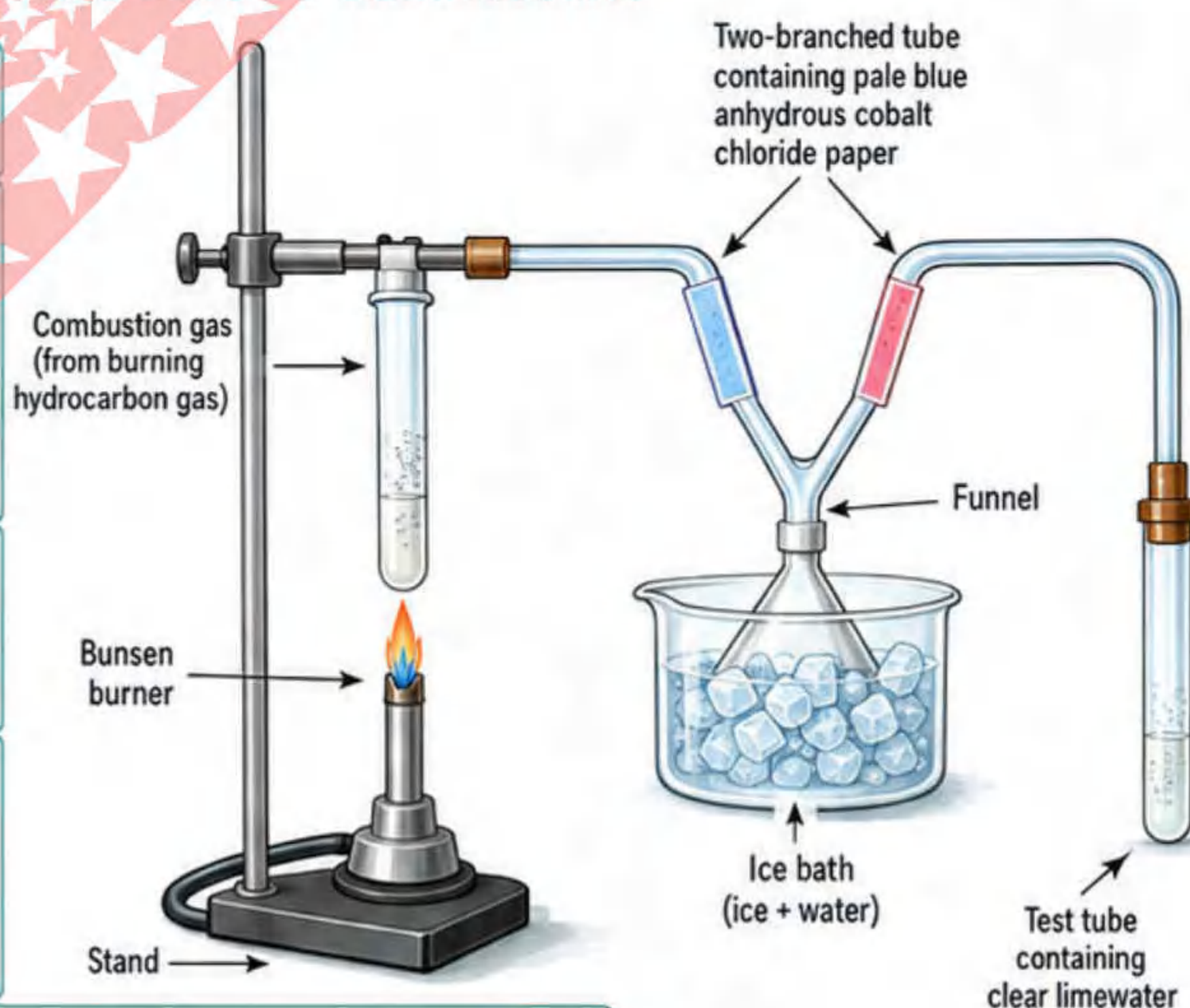
Observation:

- Water vapor produced by combustion condenses to water in the cooled part of the apparatus.
- The cobalt chloride paper changes from pale blue to pink.
- The clear limewater turns milky.



Conclusion:

- When hydrocarbon gases such as natural gas burn completely, carbon dioxide gas (CO_2) and water vapor (H_2O) are produced.
- Ice around the two-branched tube helps condense the water vapor into water.
- Limewater turns milky because it reacts with carbon dioxide.





Properties of Combustion Products



How the Products Differ and Why They Matter



The products of combustion differ according to factors such as the chemical composition of the burning substance and the amount of oxygen available for combustion.

1 Carbon Dioxide (CO₂)



- Produced by the complete combustion of carbon-containing substances such as organic materials.
- A colourless, odourless gas.
- It does not burn and does not support burning.
- It is denser than air.
- It dissolves in water to form carbonic acid (H₂CO₃).

2 Carbon Monoxide (CO)



- Produced in incomplete combustion when oxygen is insufficient.
- A poisonous, colourless, odourless gas.

3 Water Vapour (H₂O)



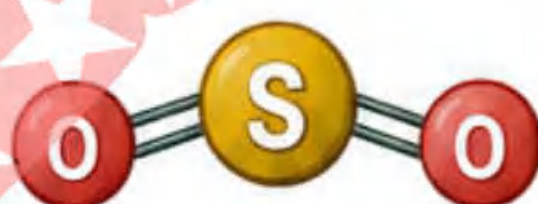
- Produced by the combustion of hydrogen and hydrogen-containing substances such as hydrocarbons.
- It condenses into water droplets when cooled.

4 Carbon / Soot (C)



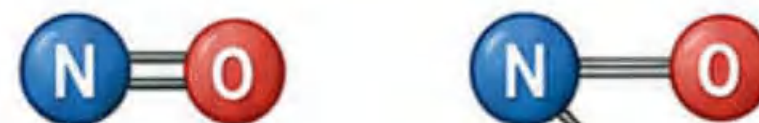
- Produced in the incomplete combustion of hydrocarbons.
- It appears as fine black solid particles that are deposited on surfaces.

5 Sulfur Dioxide (SO₂)



- Produced when fuels containing sulfur burn.
- A colourless gas with a choking smell.
- It dissolves in water to form sulfurous acid (H₂SO₃).

6 Nitrogen Oxides (NO_x)



- Produced mainly by burning nitrogen-containing compounds in fossil fuels.
- They include nitric oxide (NO), a colourless gas.
- Nitric oxide reacts quickly with oxygen in the air to form nitrogen dioxide (NO₂).
- Nitrogen dioxide is a reddish-brown gas with a sharp, choking smell.
- These gases dissolve in water to form nitrous acid (HNO₂) and nitric acid (HNO₃).



In combustion reactions, the composition of the reactants changes, but the total mass of the products equals the total mass of the reactants (Law of Conservation of Matter).



Combustion reactions can also change environmental conditions and even affect human health over time.





Combustion and Environmental Pollution



Agricultural Waste Burning and Car Exhaust

1 Burning Agricultural Waste

- Some farmers burn rice straw in the fields at the end of the harvest season, usually during October and November, to prepare the land quickly for the next crop.
- Because the straw is piled up and there is not enough oxygen inside the piles, incomplete combustion often occurs.
- Large amounts of carbon monoxide, carbon dioxide, and suspended carbon particles (soot) rise into the air.
- This forms thick smoke known as the black cloud.
- The black cloud reduces visibility, causes difficulty in breathing, and increases cases of asthma and chest allergy.



2 Combustion in Car Engines

- Burning fuel inside the car engine produces heat energy that is used to generate the mechanical energy needed to move the car.
- This combustion produces a mixture of emissions known as exhaust.
- Car exhaust contains harmful gases and substances such as carbon monoxide, carbon dioxide, carbon particles (soot), and nitrogen oxides.
- Vehicle exhaust is one of the main causes of air pollution in cities.
- Sometimes combustion inside the engine is incomplete because the amount of air supplied is low or because the engine efficiency decreases. This increases the proportion of harmful emissions.

How can this pollution be reduced?

- Regularly maintain car engines to improve their efficiency.
- Use cleaner vehicle fuels such as natural gas, or shift to electric cars.
- Depend on environmentally friendly public transportation.



3 Technology Application — Catalytic Converter

- The catalytic converter is a technological application used to reduce environmental pollution caused by fuel combustion in car engines.
- It works by using catalysts, substances that increase the rate of a chemical reaction without being changed.
- Inside the exhaust system, it speeds up oxidation and reduction reactions.
- It converts toxic gases such as carbon monoxide and nitrogen oxides into safer substances such as carbon dioxide and nitrogen.





Combustion in Industry and Cleaner Solutions



Reducing Industrial Pollution from Combustion

1 COMBUSTION IN INDUSTRY



Combustion reactions are a main source of energy in many heavy industries, such as metal smelting, ceramic production, cement and glass manufacturing, and petroleum distillation.



Many power stations depend on burning fossil fuels such as coal and natural gas to produce steam that drives turbines and then electric generators.



Pollution caused by industrial combustion can be reduced in several ways:

- 1 Rely on natural gas as a less polluting fuel.
- 2 Install filters to purify gases before they leave factory chimneys.
- 3 Use renewable energy sources such as solar energy and wind energy to generate electricity.



2 WHY IS NATURAL GAS PREFERRED OVER COAL?



Burning natural gas is less harmful to the environment. Compared with other fossil fuels, its carbon dioxide emissions are lower, and sulfur oxide emissions and carbon particulates are very low.



In contrast, burning coal produces a very high proportion of carbon dioxide and larger amounts of sulfur oxides and carbon particulates.

3 TECHNOLOGY APPLICATION – ACID GAS SCRUBBERS

- Acid gas scrubbers are a technological application used to reduce industrial pollution caused by combustion.
- Their operation depends on passing harmful acidic gases, such as sulfur dioxide, through sprays of alkaline solutions inside factory chimneys.
- Neutralization reactions take place, and safe salts are formed.
- This helps reduce acid rain and smog.



4 DESIGN CHALLENGE



Be an Environmental Engineer

Imagine you are a member of an environmental protection team. Choose one environmental problem: the black cloud, car exhaust, or burning waste. Suggest practical solutions, such as technologies that reduce harmful combustion emissions or a filter that converts harmful gases from incomplete combustion into less harmful gases.



5 CAUSE AND EFFECT



Increase in combustion processes



EFFECT

leads to emissions that disturb environmental balance

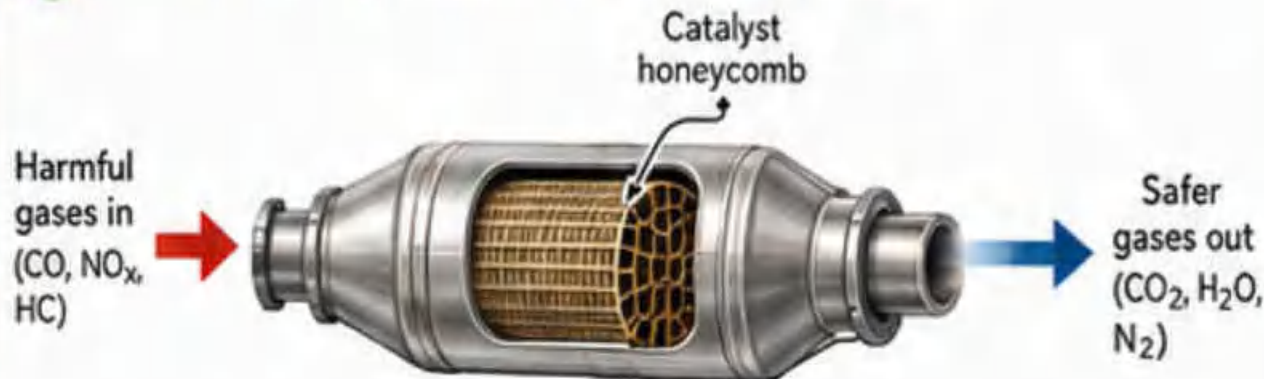


Controlling Emissions and Final Review

PAGE 16 OF 16

1 TECHNOLOGY FOR CLEANER COMBUSTION

A Catalytic Converter (Cars)



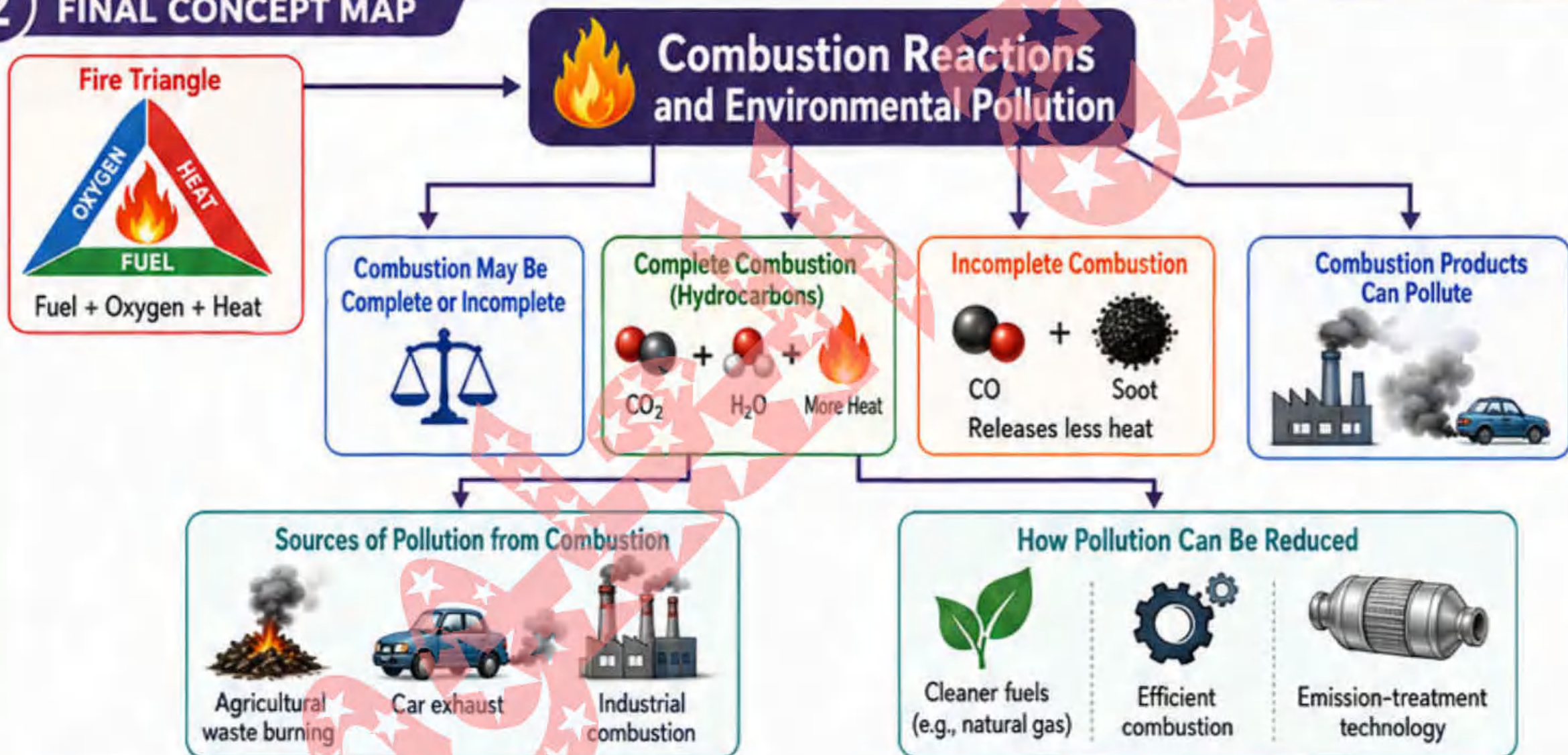
- Used to reduce environmental pollution caused by fuel combustion in car engines.
- Contains catalysts that increase the speed of chemical reactions without being changed.
- Speeds up oxidation and reduction reactions in the exhaust system.
- Converts poisonous gases such as carbon monoxide and nitrogen oxides into safer substances such as carbon dioxide and nitrogen.

B Acid-Gas Scrubber (Factories)



- A method to reduce industrial pollution caused by combustion.
- Harmful acidic gases such as sulphur dioxide pass through sprays of alkaline solutions in factory chimneys.
- A neutralisation reaction occurs.
- Safe salts form and settle.
- This helps reduce acid rain and smoky fog / smog.

2 FINAL CONCEPT MAP



3 KEY LAW AND ESSENTIAL FACTS



Key Scientific Fact

In combustion reactions, the composition of the reactants changes, but the total mass of the products equals the total mass of the reactants.

Law of Conservation of Matter

Remember

- Blue flame indicates complete combustion.
- Yellow/orange flame indicates incomplete combustion.
- Carbon monoxide is poisonous.
- Soot is fine black carbon particles.
- Natural gas is less polluting than coal.

4 DESIGN CHALLENGE / APPLICATION

Suggest practical ways to reduce pollution caused by combustion in homes, vehicles, farms, and factories.



Ensure enough air for efficient burning.



Maintain engines and burners regularly.



Use cleaner fuels or renewable energy when possible.



Use pollution-control devices such as catalytic converters and scrubbers.



Lesson Takeaway

Combustion is an important source of energy, but its products and conditions determine how safe, efficient, and environmentally harmful it can be.



Prepared by
Mr. Mohamed Ibrahim



Science Theater



Science – Grade 9 | Unit 1:
Chemical Reactions and Their Environmental Effects

16/16

D.M.RAZK

موقع الدكتور محمد رزق معلم الكيمياء التعليمي



Smoking and Its Risks



The lesson explores a behavior that threatens public health and answers three questions:

- ✓ What are the components of cigarette smoke?
- ✓ How does smoking affect human health?
- ✓ Why should people stop smoking?

KEY TERMS



Tobacco



Nicotine



Tar

Mineral
ElementsRadioactive
Elements

Emphysema

Traditional
SmokingActive
SmokingPassive
Smoking

Vaping

World Health
Organization (WHO)

LEARNING OBJECTIVES



- 1 List some chemical substances found in tobacco.
- 2 Identify the chemical substances produced by burning tobacco.
- 3 Distinguish between traditional smoking, active smoking, passive smoking, and vaping.
- 4 Evaluate the harms of different forms of smoking to smokers and to people around them.
- 5 Evaluate the effects of smoking on the environment.
- 6 Contribute to creating awareness materials against the smoking habit.



SKILLS, VALUES, AND RELATED ISSUE

**Skills:**Investigation, Communication,
Evaluating sources and reliability.**Value:**

Protecting health.

**Related issue:**The harms of ordinary cigarettes
and electronic cigarettes.

CROSS-CUTTING CONCEPT

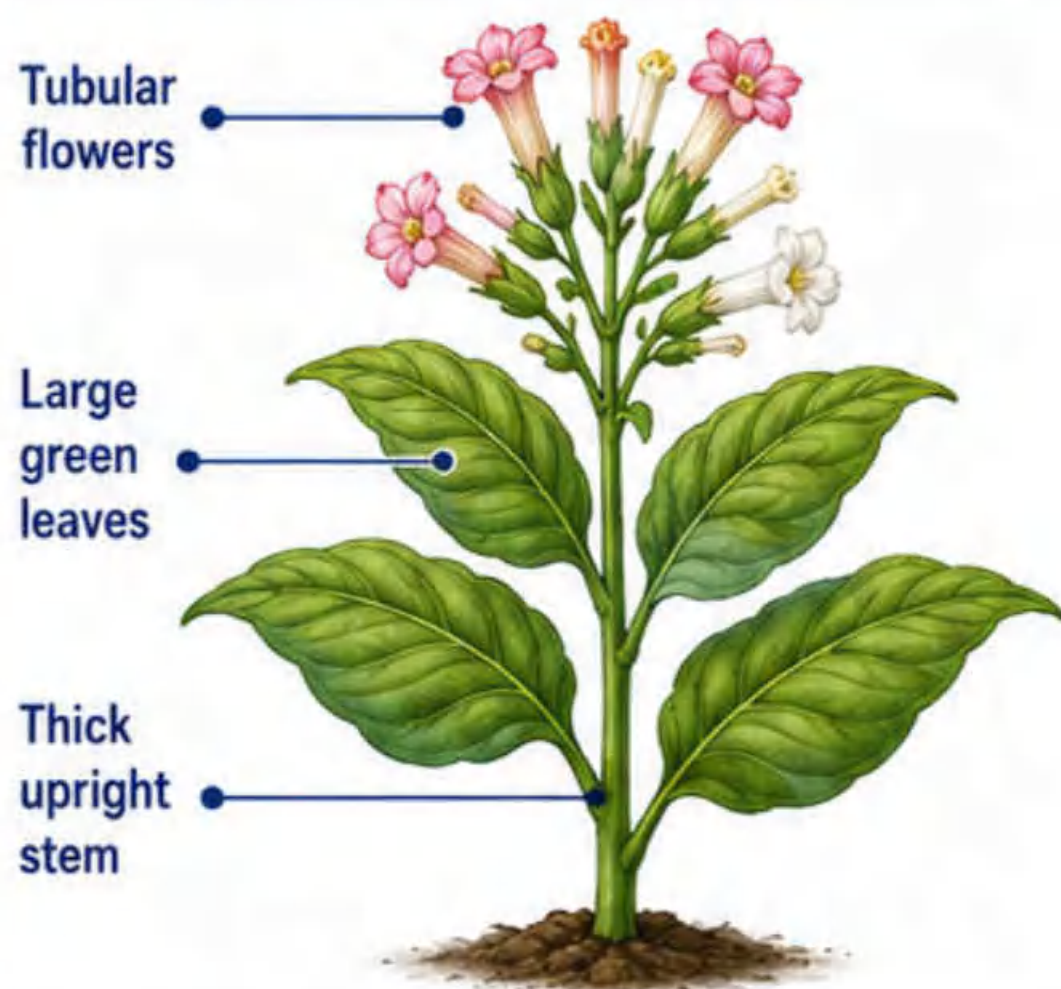


Structure and Function





Tobacco Plant and Exploring Tobacco Combustion



The tobacco plant grows mainly in warm regions, especially tropical areas. It has a thick upright stem, large green leaves, and tubular flowers that may be white, pink, or red.

KEY QUESTION



What substances does tobacco contain? What products are formed when tobacco burns?



EXPERIMENT



Aim

To obtain a sample of tobacco combustion products and identify some of them.



Tools

Transparent plastic bottle, tight stopper or lid, water filling about one third of the bottle, a cigarette, and a piece of white cotton.



Steps

- 1 Make a hole in the bottle cover and fix the cigarette tightly in it.
- 2 Place a piece of white cotton near the bottle mouth, then close the bottle tightly.
- 3 Light the cigarette and remove the stopper so the water flows downward, drawing air through the cigarette into the bottle and carrying the combustion products with it.



Observation

As cigarette smoke passes through the cotton, the cotton changes from white to dark brown.



Conclusion

Some combustion products travel with the smoke and deposit between the cotton fibers.

1

Cigarette fixed in the lid



Water level (about one third of the bottle)

2

White cotton near the mouth

**3**

Smoke fills the bottle; water flows downward



Close-up:

Brown deposits trapped in cotton





Chemical Components of Tobacco



Tobacco leaves contain many chemical substances, and burning tobacco produces a dangerous mixture of harmful gases and particles.

A Nicotine

- ✓ A natural organic compound with an alkaline effect.
- ✓ Its chemical composition includes carbon, hydrogen, and nitrogen.
- ✓ The high temperature of a burning cigarette causes nicotine to vaporize and mix with the smoke inhaled by the smoker.
- ✓ Burning tobacco also releases dangerous gases, including toxic gases such as carbon monoxide (CO) and hydrogen cyanide (HCN), and irritant gases such as nitrogen oxides (NO and NO₂) and ammonia (NH₃).

C Mineral Elements

- ✓ Tobacco contains mineral elements such as potassium, magnesium, and calcium.
- ✓ It also contains toxic heavy elements such as cadmium, lead, and arsenic.

Harmful Gases Produced by Burning Tobacco

- CO Carbon Monoxide
- HCN Hydrogen Cyanide
- NO Nitrogen Oxides (NO)
- NO₂ Nitrogen Dioxide (NO₂)
- NH₃ Ammonia

B Plant Sugars and Proteins

- ✓ These substances are naturally present in tobacco leaves.
- ✓ When they burn, they produce carbon monoxide and tar.
- ✓ Tar is a sticky liquid formed from a mixture of combustion products from sugars, proteins, and plant fibers.

D Radioactive Elements

- ✓ Small quantities of radioactive elements are present in tobacco, including Polonium-210.
- ✓ These elements are responsible for radiation damage in the smoker's lungs.

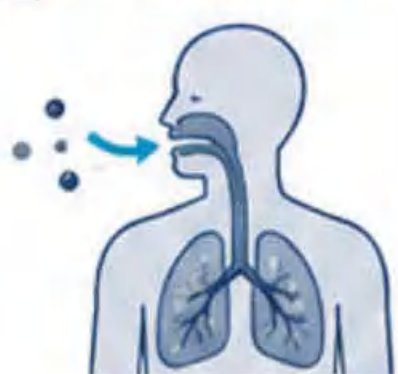
What happens to heavy metals and radioactive elements during smoking?

1 Volatilization



Some heavy metals and radioactive elements evaporate when tobacco burns, or stick to fine tar particles.

2 Inhalation



These particles enter the lungs and settle in the branches of the air passages.

3 Radioactive accumulation



Their accumulation damages DNA in lung cells and increases the risk of cancer.

4 Ash



The remaining ash contains non-volatile minerals such as calcium and potassium, giving ash its white or gray color.





Health Harms of Smoking: The Respiratory System



- ✓ When a cigarette is lit, complex chemical reactions produce thousands of chemical substances. Most of them are toxic gases and cancer-causing substances.
- ✓ Tobacco smoking is one of the greatest threats to public health. According to the World Health Organization (WHO), it causes more than 8 million deaths every year worldwide.



OBSERVE AND THINK



Healthy Lungs
(Non-Smoker)



Smoker's Lungs
(Smoker)

- ? Why do the lungs have different colors in the two cases?
- ? Which lungs are better able to supply blood with oxygen?
- ? How does lung capacity change in a smoker over time?



HOW SMOKING HARMS THE LUNGS

- ✓ Smoking changes the color of the lungs from the natural pink color to a dark or black color because tar and fine chemical particles are deposited inside the lung tissues.
- ✓ Over time, the lungs lose elasticity and their capacity gradually decreases.
- ✓ The smoker may suffer from chronic shortness of breath, persistent cough, and a noticeable decline in the ability to perform physical effort.
- ✓ Smoking also increases the risk of lung cancer.



Persistent Cough



Shortness of Breath

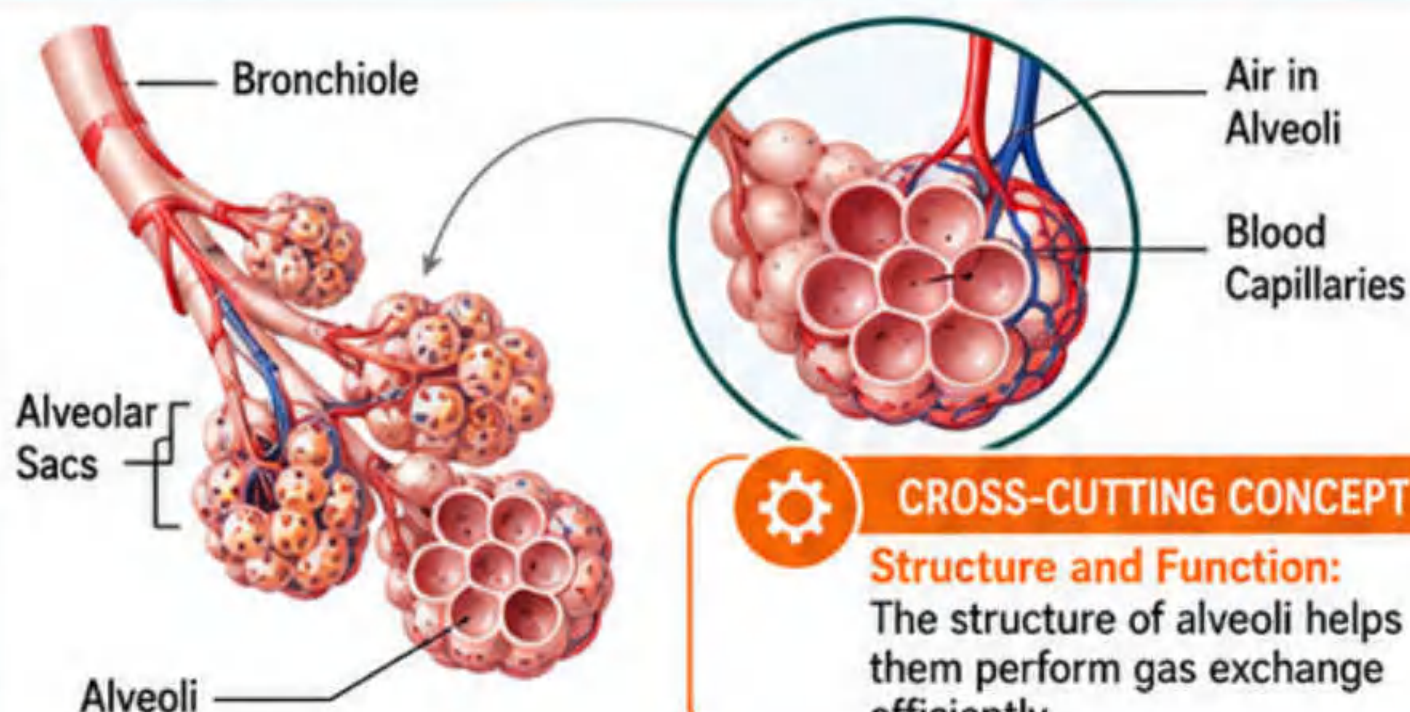


Reduced Lung Capacity



RESPIRATORY SYSTEM

- ✓ The alveoli in the lungs are tiny, thin-walled, and very numerous structures.
- ✓ This structure provides a large surface area that allows gas exchange (oxygen and carbon dioxide) between the lungs and the blood.



CROSS-CUTTING CONCEPT

Structure and Function:

The structure of alveoli helps them perform gas exchange efficiently.





Health Harms of Smoking: Other Body Systems

1 Emphysema

- Smoking may cause emphysema.
- When smoke is inhaled, sticky tar condenses and gradually deposits on the inner walls of the alveoli, causing lung tissues to lose elasticity.
- As tar continues to accumulate, the walls of the alveoli tear. Many small air sacs change into larger, weak cavities.
- As a result, the surface area available for gas exchange decreases greatly, causing severe chronic shortness of breath and reducing the amount of oxygen reaching the blood.

Alveoli: Normal vs. Damaged by Emphysema

Normal Alveoli



Many small air sacs with large surface area for gas exchange.

Alveoli Damaged by Emphysema



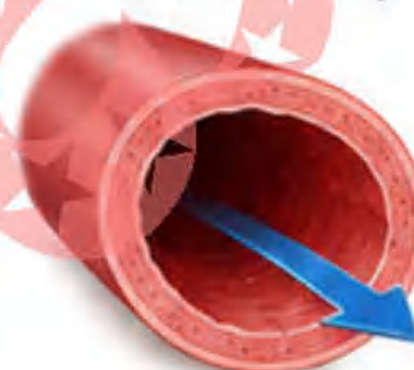
Air sacs are enlarged and destroyed, reducing the surface area.

2 Circulatory System (Heart)

- Carbon monoxide produced during smoking combines with hemoglobin much faster than oxygen does, so the amount of oxygen carried in the blood decreases.
- Nicotine increases heart rate and blood pressure and causes narrowing of blood vessels, increasing the risk of heart disease and hardening of the arteries.



Normal Artery



Wide artery with normal blood flow.

Narrowed Artery



Narrowed artery with reduced blood flow.

3 Nervous System and Senses

- Toxins from smoking may disturb the nervous system.
- Nicotine may increase tension and cause sleep disorders and vision problems.
- Over time, smoking may negatively affect brain functions and concentration, especially in adolescents.



Brain Function
May be affected over time.



Tension & Sleep
May increase tension and disturb sleep.



Vision
May cause or worsen vision problems.

4 Fertility and Reproductive Health



Smoking negatively affects fertility in both sexes and increases the risks of fetal abnormalities.

5 Immunity and General Appearance



- Smoking weakens the immune system.
- Its effects may also appear clearly as pale skin and hair loss.





Addiction and Environmental Damage



WHY IS SMOKING ADDICTIVE?



1



During smoking, nicotine reaches the brain quickly.

2



It stimulates the release of substances that cause a temporary feeling of comfort.

3



This effect disappears quickly, which pushes the person to smoke again.

4



Repeated smoking leads to addiction, so smoking becomes a harmful habit that is difficult to get rid of.



ENVIRONMENTAL HARMS OF SMOKING



1. Air Pollution

Large amounts of carbon dioxide from smoking are released into the atmosphere and contribute to global warming.



2. Water and Soil Pollution

Cigarette butts are among the most widespread wastes. They contain harmful chemicals that leak into soil and water and affect living organisms.



DID YOU KNOW? (WHO)



Smoking releases tens of millions of tons of **carbon dioxide** into the Earth's atmosphere.



Trillions of cigarette filters end up in oceans, rivers, pavements, floors, and beaches every year.



ENRICHMENT

Global warming: a rise in Earth's temperature due to an increase in the concentration of certain gases in the atmosphere.





Types of Smoking

A Traditional Smoking



It depends on burning tobacco leaves in cigarettes.



It produces dense smoke loaded with thousands of toxic chemical substances such as tar and carbon monoxide.



These substances cause severe direct harm to the lungs and the heart.

B Vaping (Electronic Smoking)



It depends on a device that heats a liquid containing nicotine to produce vapor.



This vapor contains fine particles and toxic substances released from the heating coil.



The high level of nicotine can lead to rapid addiction and may cause acute disturbances in heart function and the nervous system.

OBSERVATION SUMMARY



Smoking appears in different forms, but in each case one or more people inhale harmful substances (smoke or vapor) that negatively affect health.



OBSERVE AND INFER



1 What are the similarities and differences between the forms shown?



2 In which form does smoke or vapor enter the person's body directly?



3 In which form can smoking harm other people without their choice?





Exposure to Smoking and Prevention



The danger of smoking is not limited to its different tools and forms. It also includes the different ways people are exposed to its toxins.

A Active Smoking

A smoker intentionally inhales the smoke produced by burning tobacco, or the aerosol released from electronic smoking devices, into the lungs.



B Passive Smoking

- Non-smokers may inhale the smoke exhaled by the smoker or the smoke rising from the lit cigarette.
- This smoke contains higher concentrations of toxic and cancer-causing gases because it does not pass through the cigarette filter.
- Therefore, non-smokers may be exposed to the same heart and respiratory diseases that affect smokers.



Ways to Prevent Smoking

- 1 **Make a personal decision to refuse:** learn to say 'No' to anyone who offers smoking.
- 2 **Choose positive friends:** stay away from bad friends who encourage smoking, and stay with people who care about their health.
- 3 **Use your time well:** practice sports, read, or enjoy useful hobbies.
- 4 **Avoid smoking places:** stay away from places where smoke is common to protect yourself from passive smoking.
- 5 **Ask for help when needed:** if someone pressures you to try smoking, talk to a parent or teacher.
- 6 **Learn about the harms of smoking:** the more you know, the better you can avoid it.



Discussion Point



Is vaping less dangerous than traditional direct smoking?



Choose Health, Protect Life



Say NO to Smoking



Protect Your Lungs



Care for Your Heart



Protect Others from Smoke



Build a Healthy Future



Electric Current

Lesson Overview



This lesson explores how electric charges move in circuits and how this movement helps explain the lighting of lamps in everyday life.



Key Terms



Free Electrons:

electrons that can move freely inside metals.



Electric Cell:

a source that provides electrical energy.



Electric Current:

the flow of electric charges through a conductor.



Battery:

two or more electric cells connected together.



Electric Current Intensity:

the amount of electric charge passing through a conductor each second.



Direct Current (DC):

current with constant direction.



Conductor:

a material that allows electric charges to move through it.



Alternating Current (AC):

current whose direction changes with time.



Potential Difference:

the work needed to move one coulomb of charge between two points.



Electric Resistance:

the opposition that electric charges face while moving through a conductor.



Electromotive Force (emf):

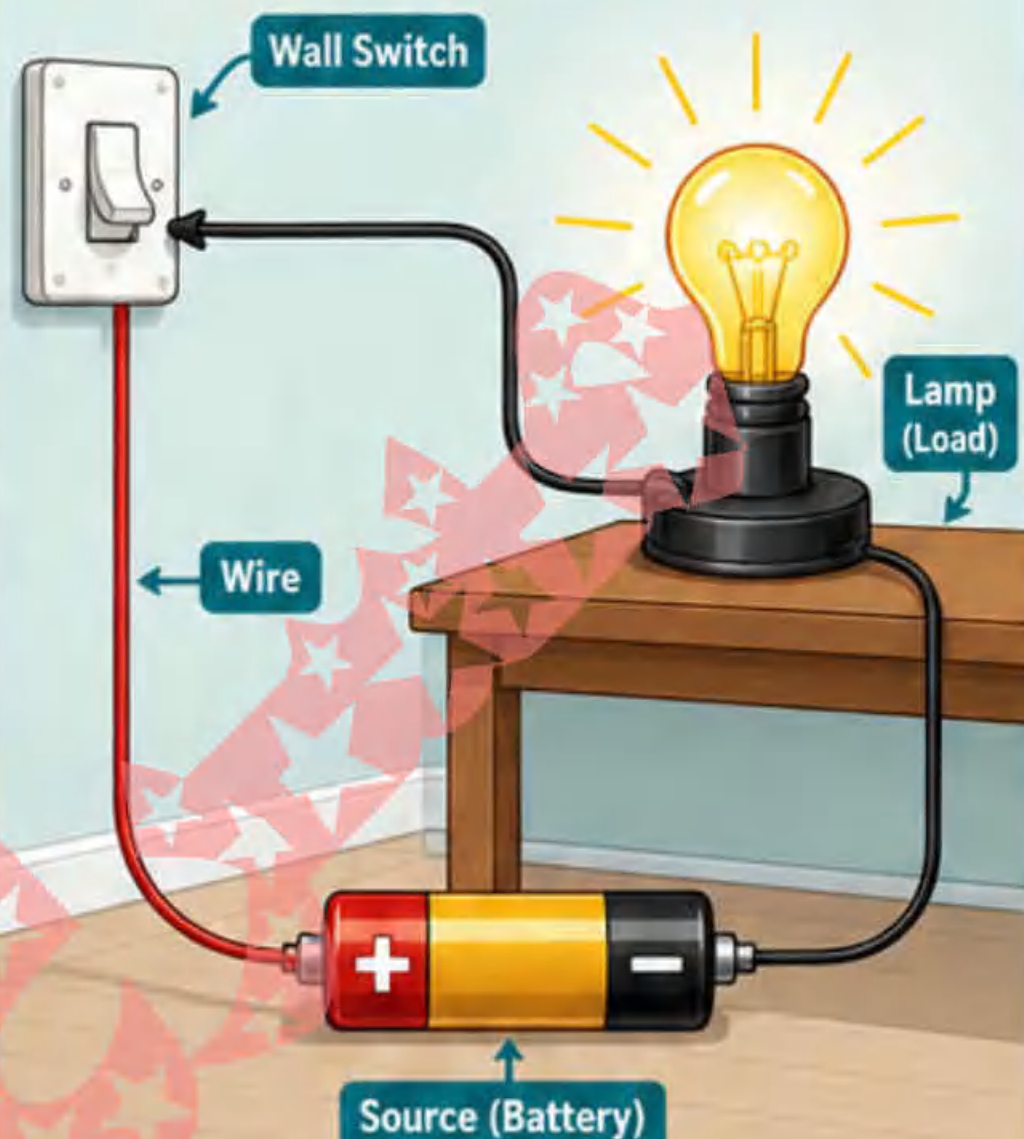
the total work done by the source to move one coulomb of charge through the whole circuit.



Lesson Goals

- 1 Define electric current and electric current intensity.
- 2 Infer the meaning of potential difference and electromotive force.
- 3 Compare connecting electric cells in series and in parallel.
- 4 Identify the types of electric resistance.
- 5 Infer the factors that affect the electrical resistance of a conductor.
- 6 Appreciate the role of scientists in inventing and developing electrical devices for human benefit.
- 7 Design a simple electric circuit using standard scientific symbols.

A Simple Home Lighting Circuit



When the switch is closed, electric current flows through the circuit and the lamp lights up.



Big Questions

- 1 Why do lamps light up as soon as the switch is pressed?
- 2 Why do some lamps shine more brightly than others?
- 3 Can the brightness of lamps be controlled?



Skills, Values, and Cross-Cutting Concept



Skills: practical work, communication, mathematical thinking, data analysis.



Values: cooperation, self-care, conserving resources.



Cross-cutting concept: Cause and Effect.

Free Electrons and Electric Current

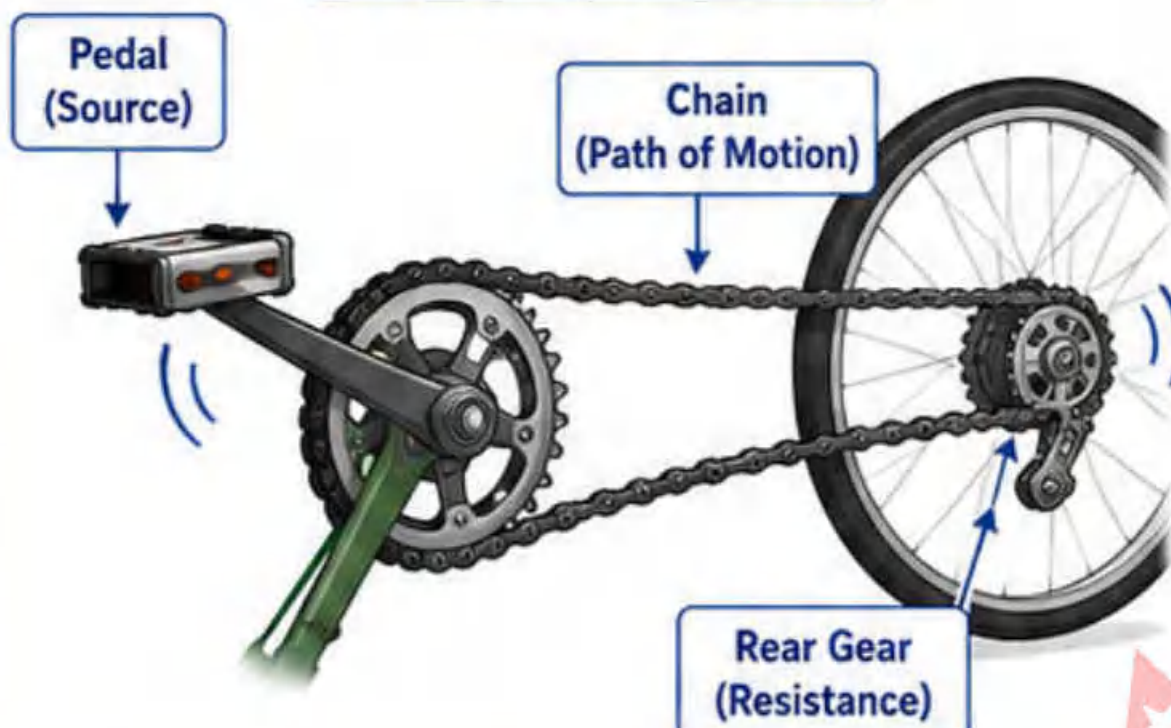
How Current Starts in a Circuit



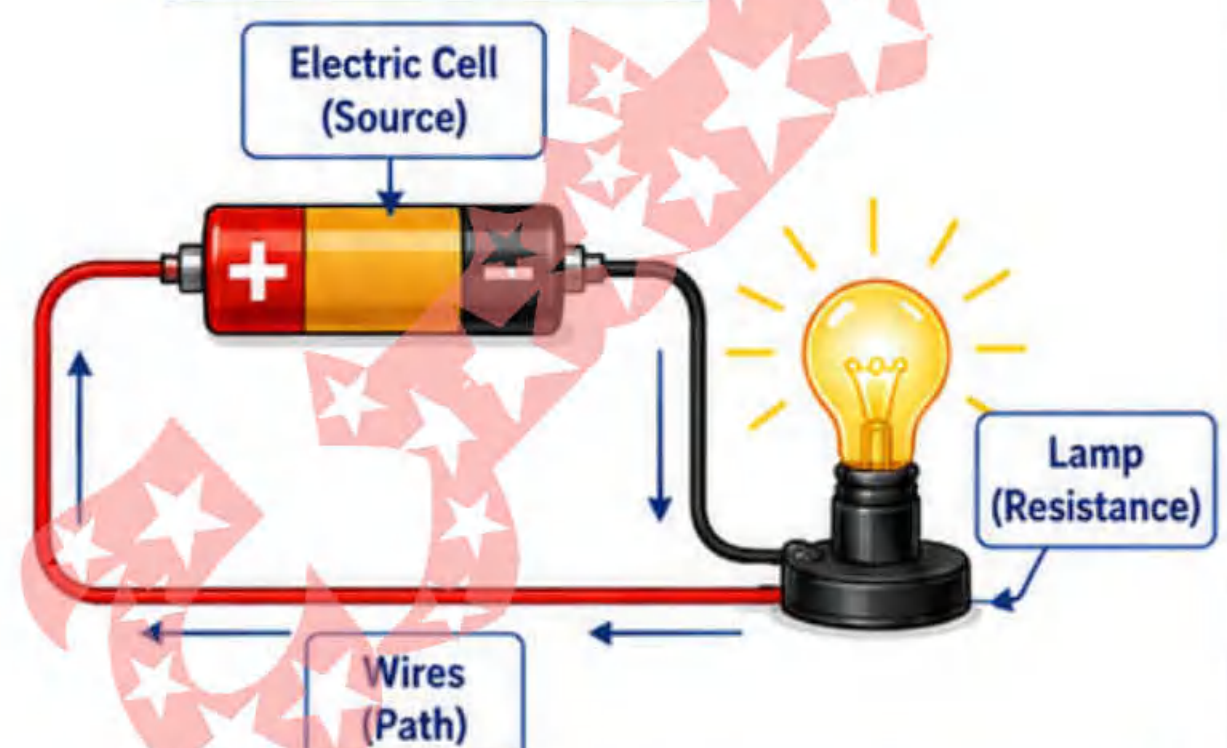
Metals such as copper and aluminium conduct electricity well because some of their electrons can become free. These free electrons act as moving electric charges inside the metal.

Analogy: Bicycle Motion System and Simple Electric Circuit

Bicycle Motion System



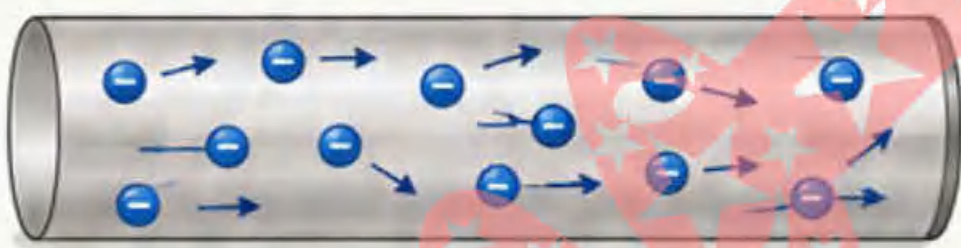
Simple Electric Circuit



Just as the pedal makes the chain move, the electric cell makes the electric charges move. When the pedal moves, the chain moves; when the circuit is closed, electric charges move.

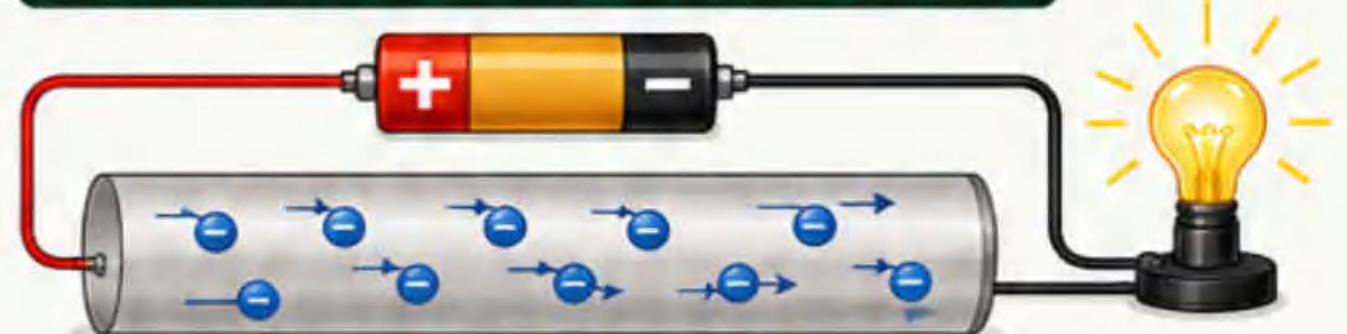
From Random Motion to Directed Flow

Free Electrons in a Metal (Random Motion)



In metals, free electrons move randomly in all directions.

Free Electrons in a Closed Circuit (Directed Flow)



When the metallic parts are connected in a closed circuit, the electric cell pushes the free electrons in one direction through a continuous path.



Electric current is the flow of electric charges through a conductor.

Conditions Needed for Electric Current

- 1 There must be an electric source to push the electric charges.



- 2 The circuit must be closed so the charges can move through a complete path.



Did You Know?



Electric current explains why a lamp lights when the circuit is completed.

Electric Current Intensity

How We Measure the Rate of Charge Flow



Think About a Race!

Imagine cars crossing a finish line. The greater the number of cars that cross the line in one second, the higher the rate of flow. This is similar to charge flow in a circuit.



Electric current intensity expresses the amount of electric charge that passes through a cross-section of a conductor each second.



Formula

$$I = \frac{Q}{t}$$

Where:

- I = electric current intensity
- Q = electric charge
- t = time



Units

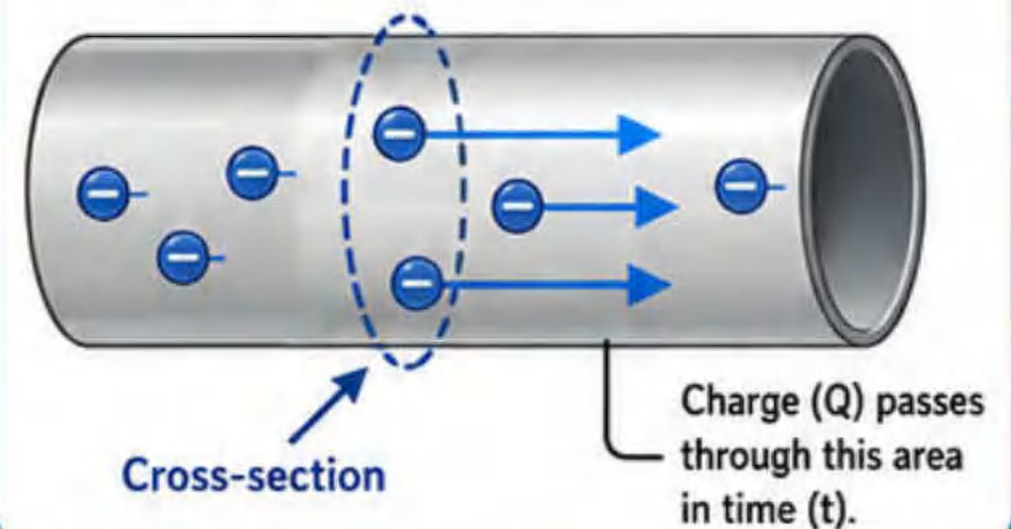
The unit of electric current intensity is the ampere (A). It is equivalent to coulomb per second (C/s).

$$1 \text{ A} = 1 \text{ C/s}$$



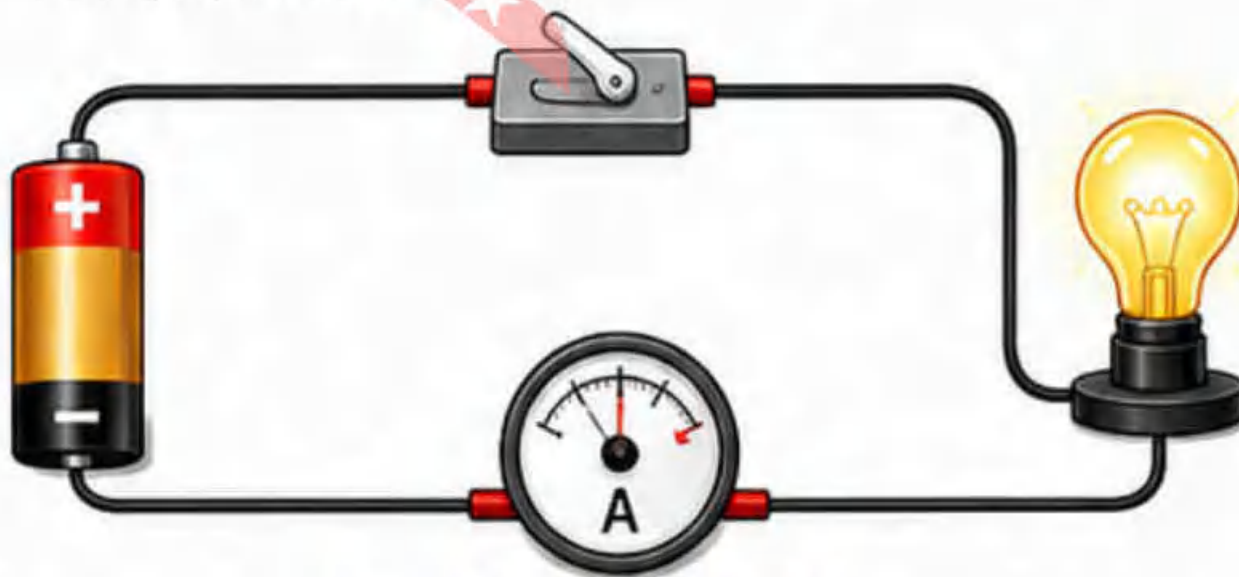
Charge Through a Conductor

Electric charge (Q) moves through the cross-section of a conductor.



Measuring Current

An ammeter is used to measure electric current intensity. It must be connected in series with the part of the circuit whose current is measured.



Ammeter connected in series



Important Note



An ammeter must be placed in series because the same current passes through it and the measured part of the circuit.



If connected in parallel, the ammeter could short the circuit and give an incorrect reading.

Potential Difference Between Two Points

Why Charges Move in a Circuit

Predict and Infer

Aim

To understand potential difference using a water model.

Tools

Two transparent containers, X and Y, connected by a tube with a valve.

Steps

- 1 Pour water into both containers while the valve is closed so that the water level in container X is higher than in container Y.
- 2 Open the valve.

Observation

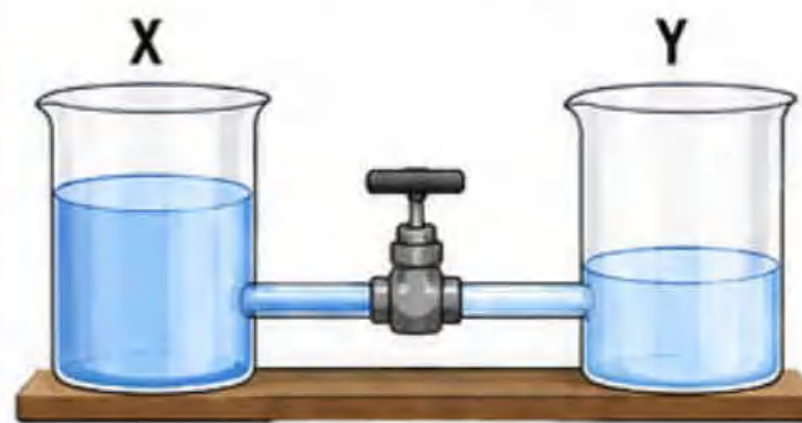
Water flows from X to Y until the water levels become equal.

Conclusion

The difference in water level produces a pressure difference that causes the water to flow.

1 Valve Closed

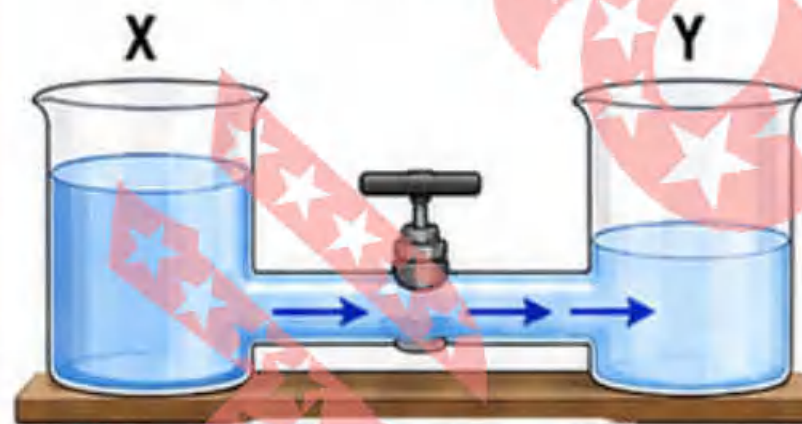
Different Water Levels



No flow

2 Valve Open

Water Flows from X to Y



Flow from X to Y

3 Valve Open

Equal Water Levels



Flow stops

The Electric Analogy

Similarly, electric charges move through a conductor from a point of higher electric potential to a point of lower electric potential.

A potential difference across a conductor causes electric current to pass through it.

Note

No electric current passes between two points in a circuit if there is no potential difference between them.

Direction of Electric Current

Scientists agreed to represent the direction of electric current in the circuit from the positive terminal of the source (higher potential) to the negative terminal (lower potential).



Enrichment Note

Free electrons themselves move from the negative terminal toward the positive terminal.



Potential Difference, Electric Sources, and emf

Measuring Voltage and Understanding Sources



Potential difference between two points is the work needed to move one coulomb of electric charge between these two points.

Formula

$$V = \frac{W}{Q}$$

Where:

V = potential difference

W = work done

Q = electric charge

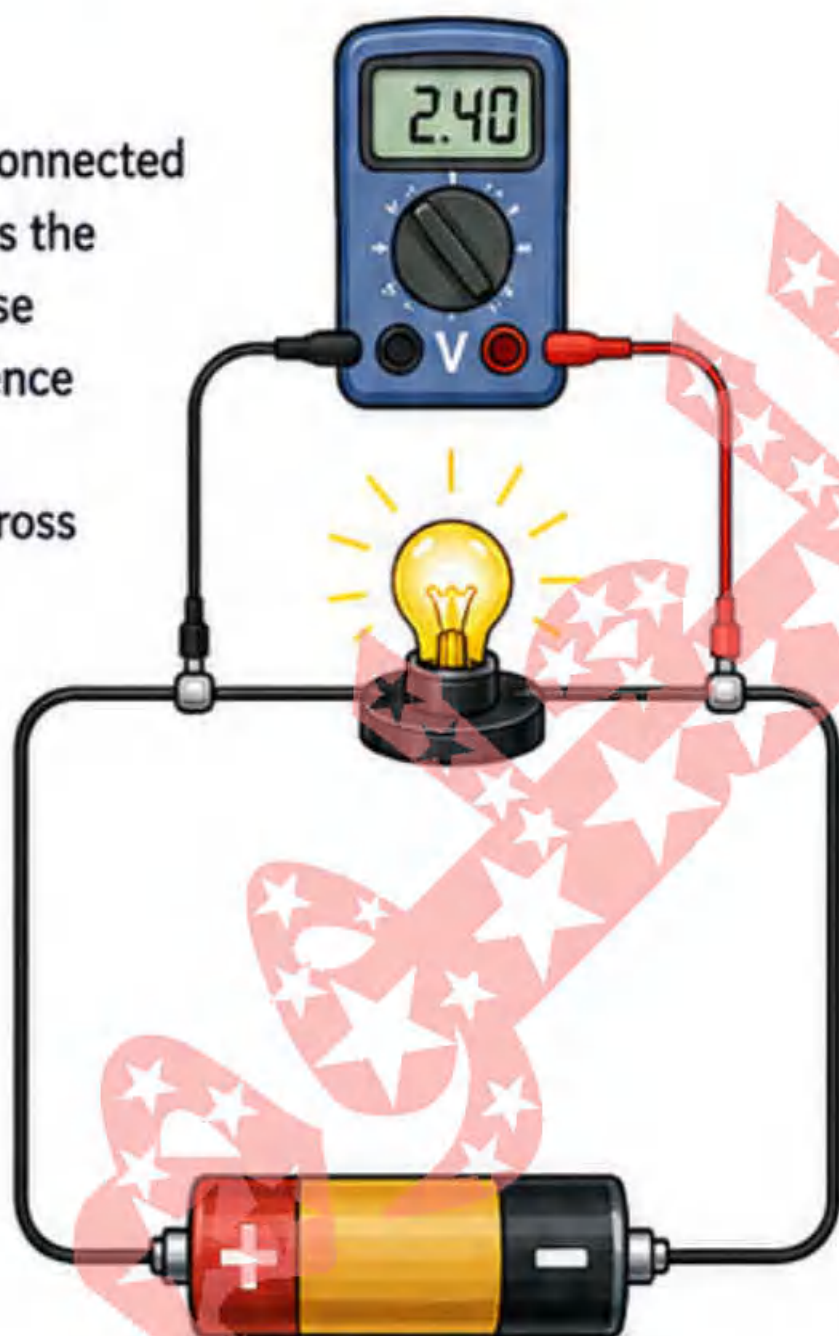
Units



Potential difference is measured in volt (V), equivalent to joule per coulomb (J/C).

Measuring Potential Difference

A voltmeter is connected in parallel across the two points whose potential difference is measured. For example, across a lamp.



Electric Source

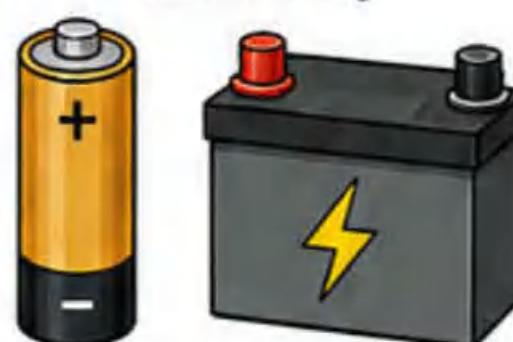
An electric source is the source of electrical energy in the circuit and is responsible for pushing electric charges through it.



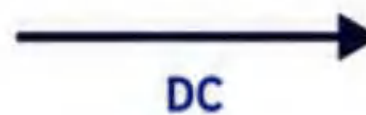
Two Types of Electric Sources

Continuous Voltage Source

Electric cell and battery



It supplies direct current (DC), which has constant intensity and one direction.



Alternating Voltage Source

Electric generator



It supplies alternating current (AC), whose intensity and direction change with time.



Electromotive force (emf) is the total work done by the source to move one coulomb of electric charge through a complete electric circuit.

Symbol: ϵ

It is also measured in volt (V).



In this unit, the internal resistance of the electric sources used is considered negligible, so the potential difference between the battery terminals is taken as equal to its emf.

Connecting Electric Cells

Series and Parallel Connections



One electric cell may not provide enough emf to operate some devices, so several cells may be connected together. A group of connected cells is called a **battery**.

Try and Infer



Tools

- Five identical electric cells, each 1.5 V
- Connecting wires
- Three identical small lamps
- Three voltmeters
- A switch



Setup

Form three original circuit diagrams:

Circuit (1):

One cell with a lamp and voltmeter.



Circuit (2):

Two identical cells connected in series with a lamp and voltmeter.



Circuit (3):

Two identical cells connected in parallel with a lamp and voltmeter.



Observation

Lamp brightness and voltmeter readings:

Circuit (1):

The lamp glows with normal brightness.



Circuit (2):

The lamp glows more brightly than in circuit (1).



Circuit (3):

The lamp has nearly the same brightness as in circuit (1).



Conclusion

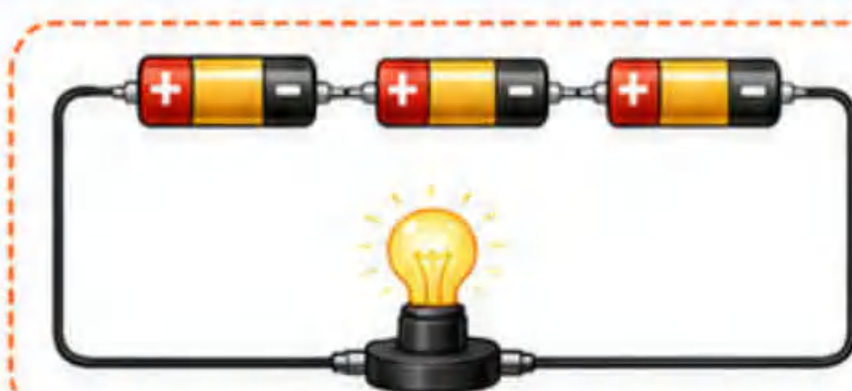
- Connecting cells in series increases the total emf.
- Connecting identical cells in parallel keeps the emf equal to that of one cell.



Math Application

If three identical cells each have emf = 3 V and are connected in series, then the potential difference across the lamp equals the total emf:

$$V_{(\text{lamp})} = \mathcal{E}_{(\text{total})} = \text{number of cells} \times \mathcal{E}_{(\text{one cell})} = 3 \times 3 = 9 \text{ V}$$



Two Ways to Connect Identical Cells

Series Connection

The positive terminal of one cell is connected to the negative terminal of the next cell.



The emf of the battery equals the sum of the emfs of the connected cells.

Parallel Connection

All positive terminals are connected together and all negative terminals are connected together.



The emf of the battery equals the emf of one cell.

Applications in Daily Life

Flashlight



Cells are connected in series to obtain a larger emf.

Portable Charger



Some chargers contain several cells connected in parallel, allowing the phone to be charged several times without increasing the output voltage.



Electric Resistance



Opposition to the Movement of Charges



Electric resistance is the opposition that electric charges face while moving through conductors.

Units and Symbols



Resistance is represented by R.



It is measured in ohm (Ω).

1 Fixed Resistance



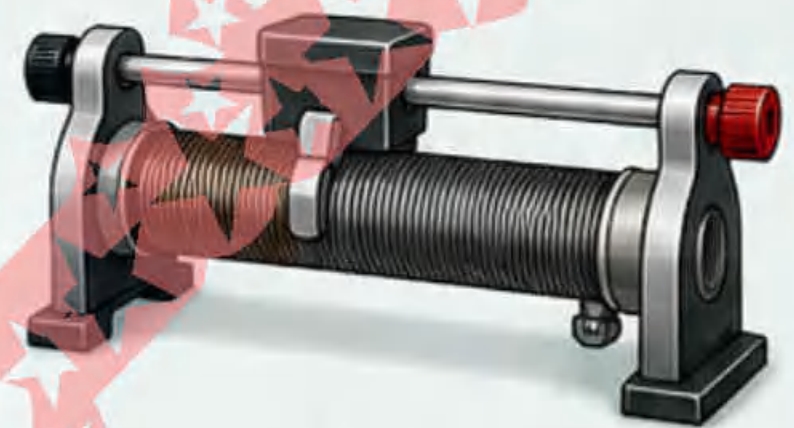
A conductor that has a specific electrical resistance is called a fixed resistor.

2 Measuring Resistance



To measure the value of a resistor, the resistor is connected between the two terminals of the ohmmeter.

3 Variable Resistance

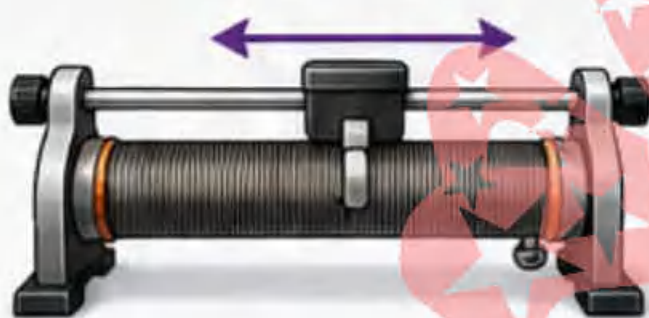


The value of the resistance can be changed, and this type is called a variable resistor.

A sliding rheostat is used to control the current intensity in a circuit.

4 How Does the Rheostat Work?

1 The slider changes the length of the wire through which current passes.



2 When the length of the wire increases, the electrical resistance increases.



Shorter length
Lower resistance

Longer length
Higher resistance

3 Therefore, the current intensity decreases.

Lower resistance → Higher current



Higher resistance → Lower current



5 Daily Life Application



Controlling the Volume of a Radio

When the knob is turned, the value of the electrical resistance changes, so the current changes and the sound intensity changes.

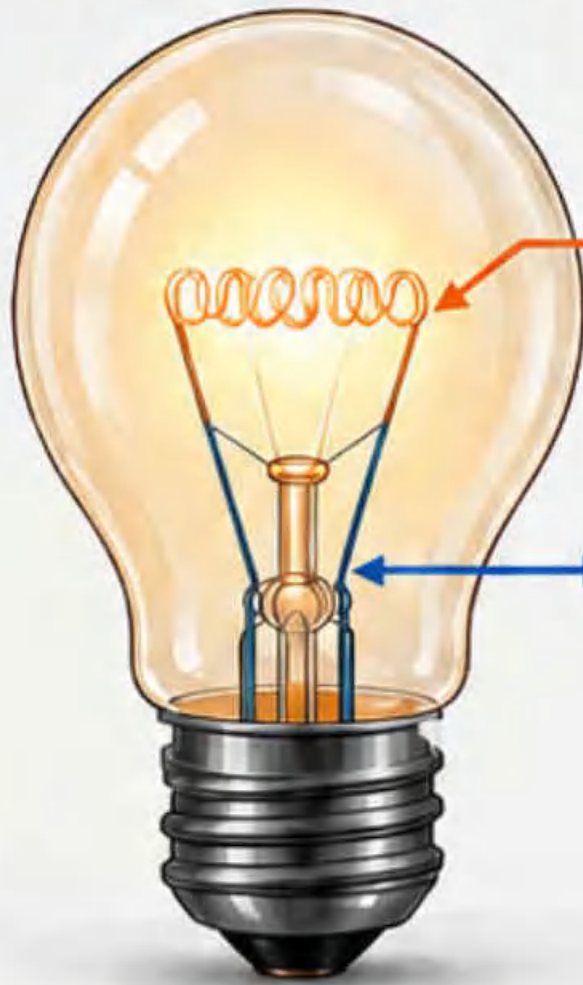
Turn toward MAX → Lower resistance → Higher current → Louder sound

Turn toward MIN → Higher resistance → Lower current → Softer sound

Factors Affecting Resistance

Why Some Wires Heat and Glow

Observation: An Incandescent Lamp



Tungsten filament wire

Copper connecting wire

An incandescent lamp contains two kinds of wires.

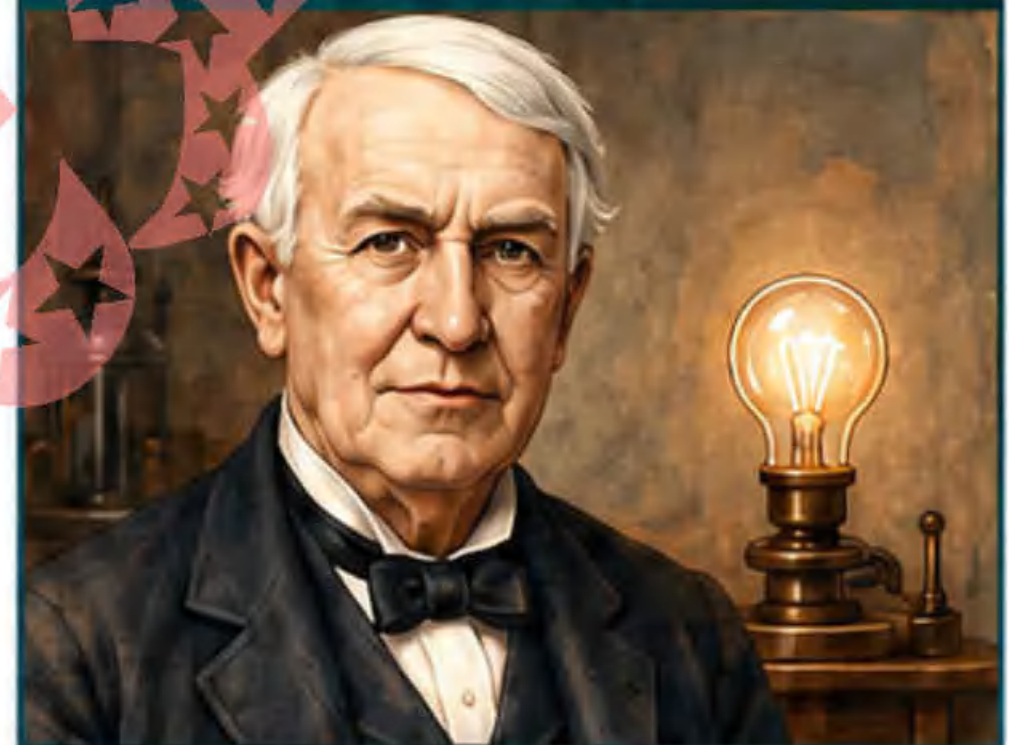
When electric current passes through the lamp, only the thin tungsten filament glows.

Inference



Every conductor (wire) has **electrical resistance**.

Scientist Spotlight: Thomas Edison (1847–1931)



American inventor.



Invented many devices that had a great effect on humanity.



Examples include the phonograph (sound recording device), the motion picture camera and moving pictures.



Developed the long-lasting electric lamp and the electric generator.

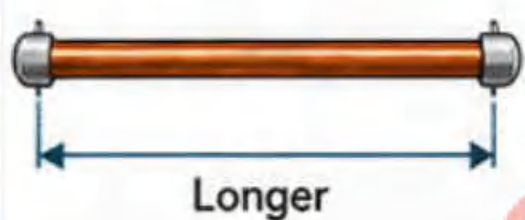


Held 1093 U.S. patents, in addition to many patents in France and Germany.

At a Given Temperature, Resistance Increases When...

1

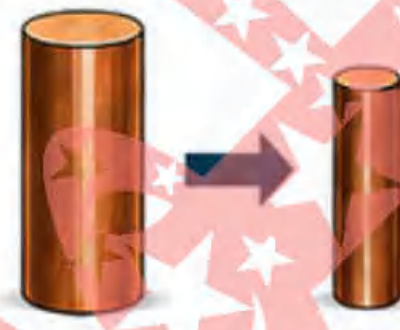
The length of the conductor increases.



Longer

2

The cross-sectional area decreases (the wire becomes thinner).



Thick (Lower R)

Thin (Higher R)

3

The material has a larger resistivity (each material has its own characteristic resistivity).



Worked Explanation: Using the Incandescent Lamp



The **filament wire** is thin, relatively long, coiled, and made of tungsten (which has high resistivity).

The **connecting wire** is thicker, relatively shorter, and made of copper (which has lower resistivity).

Therefore, the filament has a **much greater electrical resistance** than the connecting wire.

Heat Note



When a current of a certain intensity passes through a wire, the amount of heat produced increases when the wire has a higher electrical resistance.



Representing Electric Circuits

Standard Symbols and Schematic Diagrams



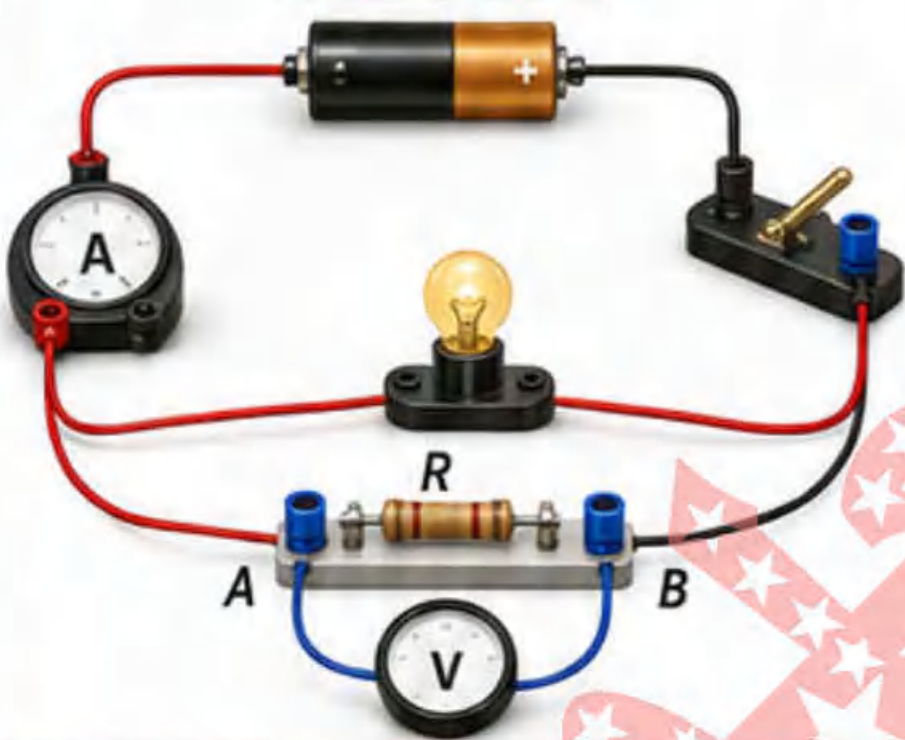
Many electrical devices contain several different components. To design and maintain these devices, engineers use agreed scientific symbols to represent the components in a simple schematic form.

Components of the Electric Circuit

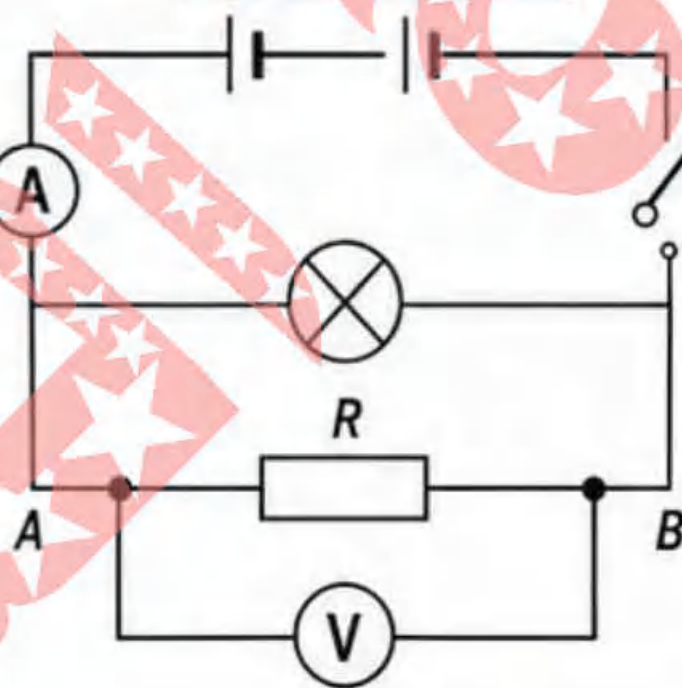
Component	Symbol	Component	Symbol
Electric cell		Fixed resistor	
Battery		Ammeter	
Open switch		Variable resistor (rheostat)	
Electric lamp		Voltmeter	

Example

Pictorial circuit



Schematic diagram



Method

- 1 Identify the suitable symbol for each component from the table.
- 2 Keep the same method of connection when drawing the schematic.

Check Your Understanding



? Draw the schematic diagram of the circuit shown using the correct scientific symbols.

Key Terms to Remember



Electric current:
flow of electric charges through a conductor.



Electric current intensity:
charge passing through a conductor each second.



Potential difference:
work needed to move one coulomb between two points.



Electromotive force (emf):
total work done by the source to move one coulomb through the whole circuit.



Electric resistance:
opposition to charge movement through a conductor.



ICT

You can design different electric circuits using interactive simulations available on websites such as PhET.

Electrical Circuits

1/7



1 LESSON VOCABULARY

- Ohm's Law
- Series Connection
- Parallel Connection
- Equivalent Resistance
- Energy Efficiency Label
- Electric Power
- Electric Energy
- Compact Fluorescent Lamp (CFL)
- Light-Emitting Diode (LED)



2 LEARNING GOALS

- 1 Verify Ohm's law experimentally and graphically.
- 2 Compare series and parallel resistor connections.
- 3 Calculate the equivalent resistance of several identical resistors connected in series and in parallel.
- 4 Explain the concept of electric power.
- 5 Calculate the cost of electrical energy consumed at home.
- 6 Appreciate the importance of safety procedures when dealing with electricity.



3 SKILLS • VALUES • ISSUES



SKILLS

- Practical work
- Measurement
- Communication
- Data analysis
- Mathematics
- Evaluating sources and reliability



VALUES

- Cooperation
- Self-confidence
- Communication



ISSUES

- Financial awareness
- Commitment to rules and law
- Conservation of resources

4

CROSSCUTTING CONCEPT



Cause and Effect



SAFETY FOCUS

Safe procedures are essential when dealing with electricity.



5 LESSON STARTER



Many lamps are used in our homes to provide light for different spaces. The way these lamps are connected affects how they work and how much energy they use.



6 INQUIRY QUESTIONS

- 1 What happens to the lamps if one lamp is damaged or switched off?
- 2 How are electrical devices connected together at home, and how does the method of connection affect current and potential difference across each device?
- 3 How can we estimate the monthly cost of electrical energy consumed at home?

Ohm's Law – Investigate and Interpret Data

2/7

i Electric current flows through a conductor because of a potential difference (voltage) between its two ends. Electrical resistance opposes this flow.



1 ACTIVITY: TEST AND EXPLAIN THE DATA



Aim

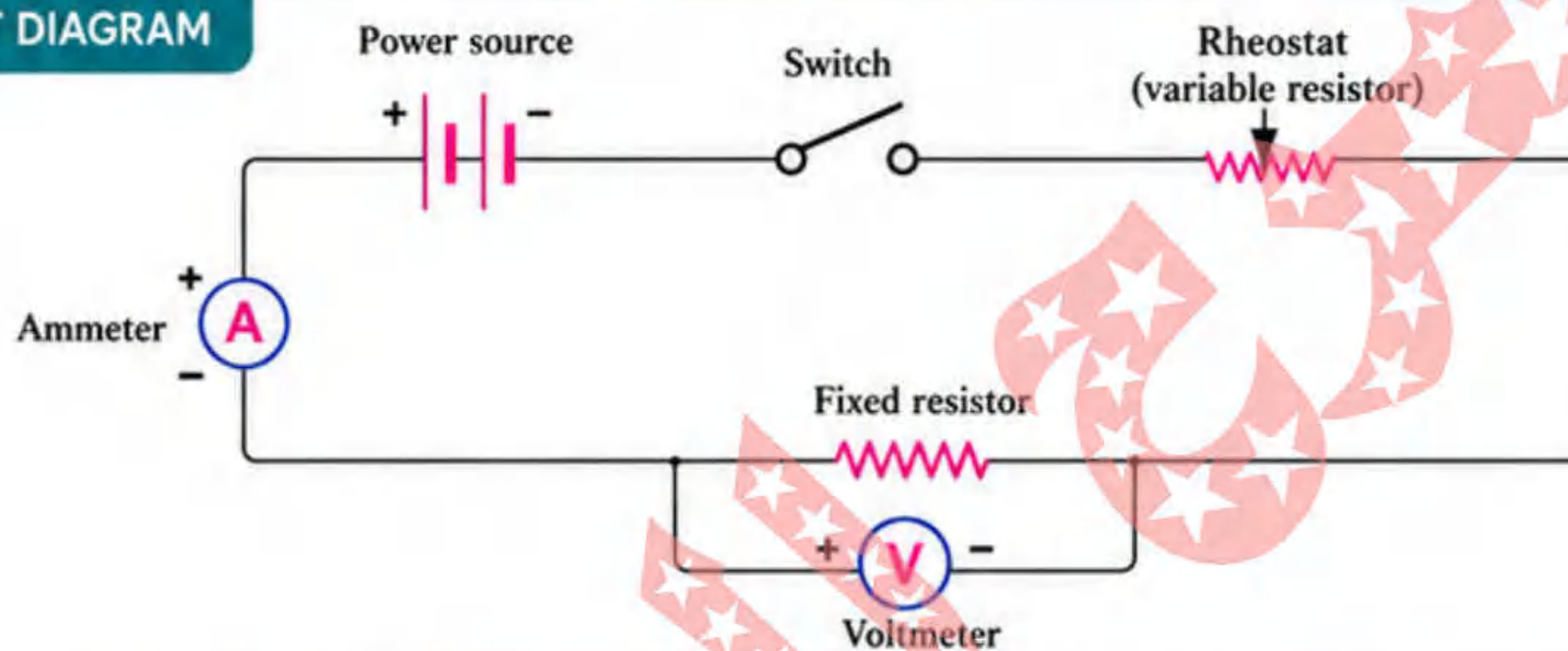
Verify Ohm's law experimentally.



2 TOOLS

- Electric source (battery)
- Fixed resistor
- Connecting wires
- Electric switch
- Variable resistor (rheostat)
- Ammeter
- Voltmeter

3 CIRCUIT DIAGRAM



PROCEDURE

- Assemble the circuit as shown in the diagram.
- Set the variable resistor (rheostat) to its maximum value to obtain the smallest possible current and protect the components.
- Close the switch and record the voltmeter and ammeter readings.
- Reduce the value of the variable resistor.
- Record the new voltmeter and ammeter readings.
- Repeat the previous two steps several times.
- Record the results in a table.
- Represent the relationship graphically.

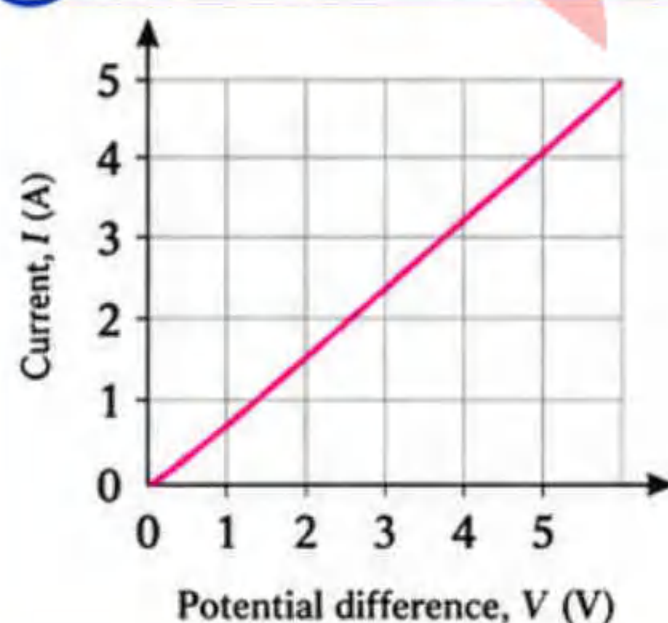


RESULTS TABLE

Voltmeter Reading (V)	Ammeter Reading (A)
.....	
.....	
.....	
.....	
.....	



GRAPHICAL REPRESENTATION



Plot current (I) on the vertical axis and potential difference (V) on the horizontal axis.



OBSERVATION

The graph is a straight line that passes through the origin (0,0).



CONCLUSION

The current through a conductor is directly proportional to the potential difference across it, provided that the temperature remains constant.

$$I \propto V \quad (T = \text{constant})$$

Ohm's Law – Formula and Applications

3/7



1 KEY IDEA

- When the relationship between current through a fixed resistor and potential difference across it is represented graphically, we obtain a straight line through the origin.



2 STATEMENT OF OHM'S LAW

- The current through a conductor (a fixed resistor) is directly proportional to the potential difference between its ends, provided the temperature remains constant.



3 MATHEMATICAL FORM

$$R = \frac{V}{I}$$

or

$$I = \frac{V}{R}$$

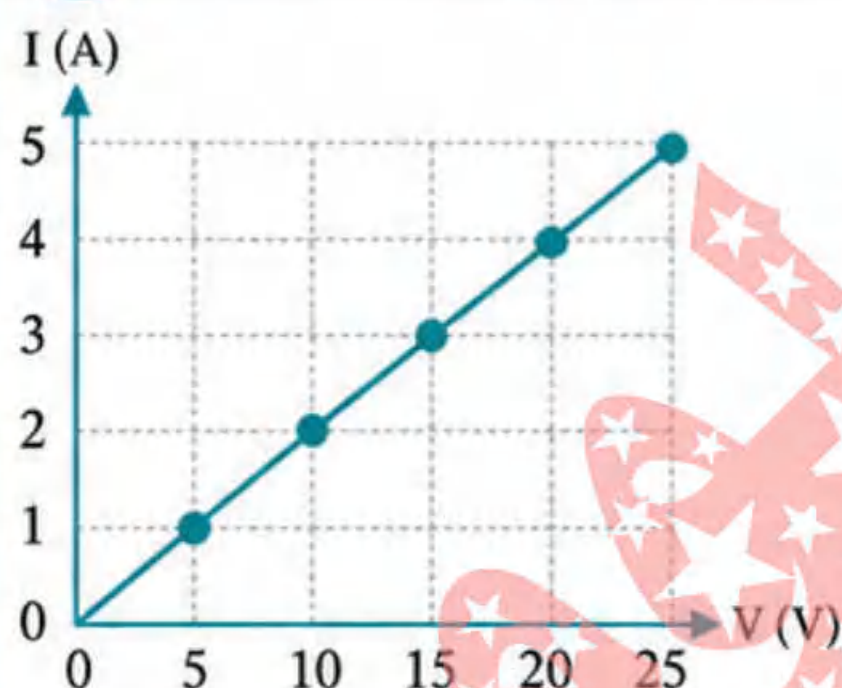
or

$$V = I \times R$$

where R is resistance (Ω), V is potential difference (V), and I is current (A).



4 RESISTANCE FROM A GRAPH



The slope of the I-V graph equals $\frac{\Delta I}{\Delta V}$, so the resistance is the inverse of the slope.

$$R = \frac{\Delta V}{\Delta I} = \frac{V_2 - V_1}{I_2 - I_1}$$

Choose any two points on the straight line to find R .



5 WORKED EXAMPLE

Problem:

A metal wire has a resistance of $2\ \Omega$ and a potential difference of $6\ \text{V}$ across its ends. Find the current.

Solution:

$$I = \frac{V}{R} = \frac{6}{2} = 3\ \text{A}$$



6 SCIENTIST SPOTLIGHT



Georg Simon Ohm (1789–1854)

- German physicist who discovered a law in electricity that is named after him.
- He discovered the relationship among quantities related to electric current.
- The unit of electrical resistance is named after him.



7 QUICK CHECK

In the Ohm's law investigation, identify:

- I** Dependent variable: Current (I)
- V** Independent variable: Potential difference (V)
- T** Constant factor: Temperature, while using the same fixed resistor.

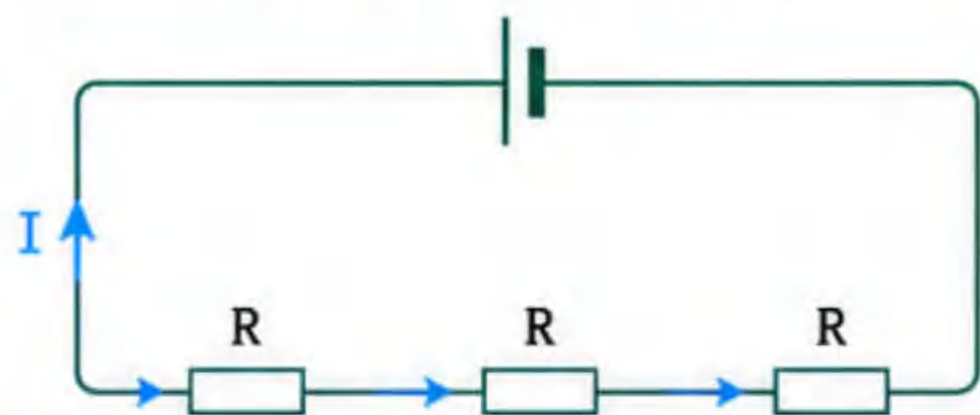


Connecting Identical Resistors



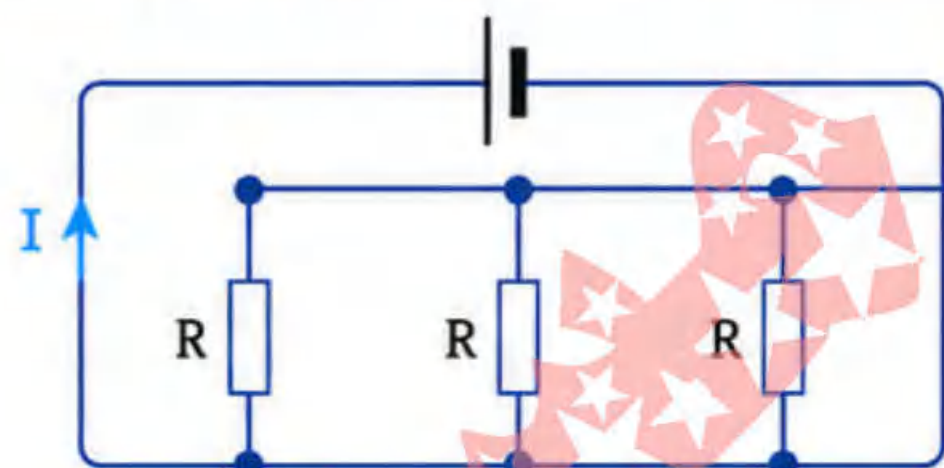
In simple electric circuits we may use one resistor, but in practical applications and devices we often connect several resistors together.

1 Series Connection



Resistors connected end to end in a single path.

2 Parallel Connection



Resistors connected across the same two points in separate paths.

Comparison	Series Connection	Parallel Connection
Method of connection	One continuous path for current.	Branched paths for current.
Current	The same current passes through all identical resistors.	Current is shared equally among identical resistors.
Potential difference	The potential difference is divided equally across identical resistors.	The potential difference across each identical resistor is the same.
Equivalent resistance of N identical resistors	$R_{eq} = N \times R$	$R_{eq} = R \div N$
Compared with one resistor	The equivalent resistance is greater than one resistor.	The equivalent resistance is less than one resistor.
Purpose	To obtain a large equivalent resistance.	To obtain a small equivalent resistance.



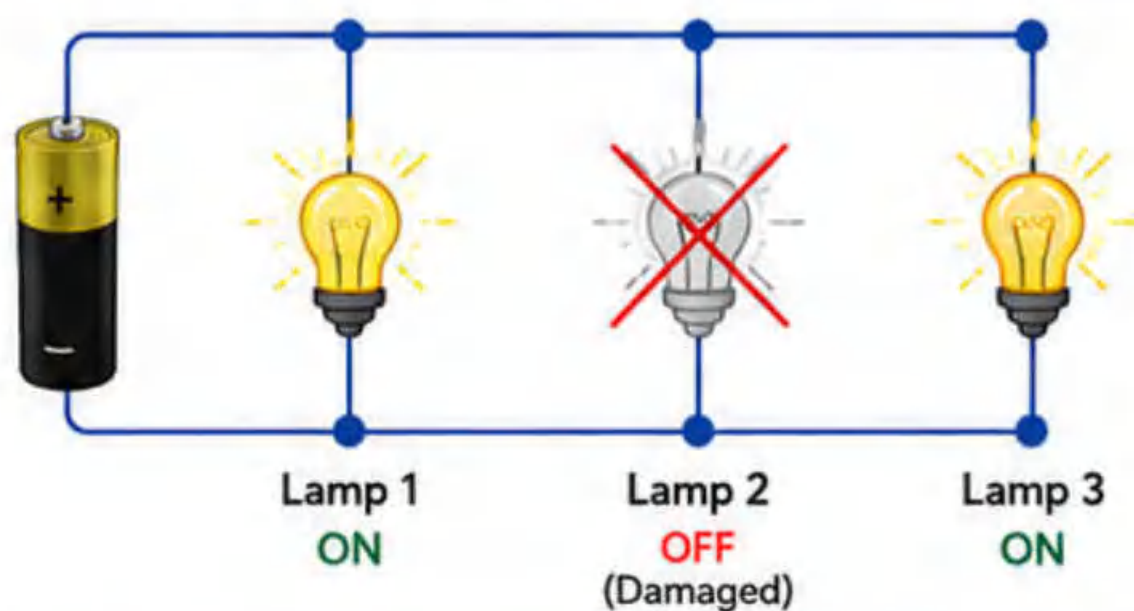
Important Note

Equivalent resistance means the single resistance that has the same effect as a group of connected resistors on the properties of the circuit.



In Daily Life

Home electrical appliances are connected in parallel so that each device can operate independently. If one device is disconnected or damaged, the other devices continue to work because each device has its own path with the source.



Equivalent Resistance in Use 5/7



1 WORKED EXAMPLE

Three identical resistors are connected in series to an electric source of **12 V**.
The current in the circuit is **2 A**.
Find the resistance of one resistor.

Solution:

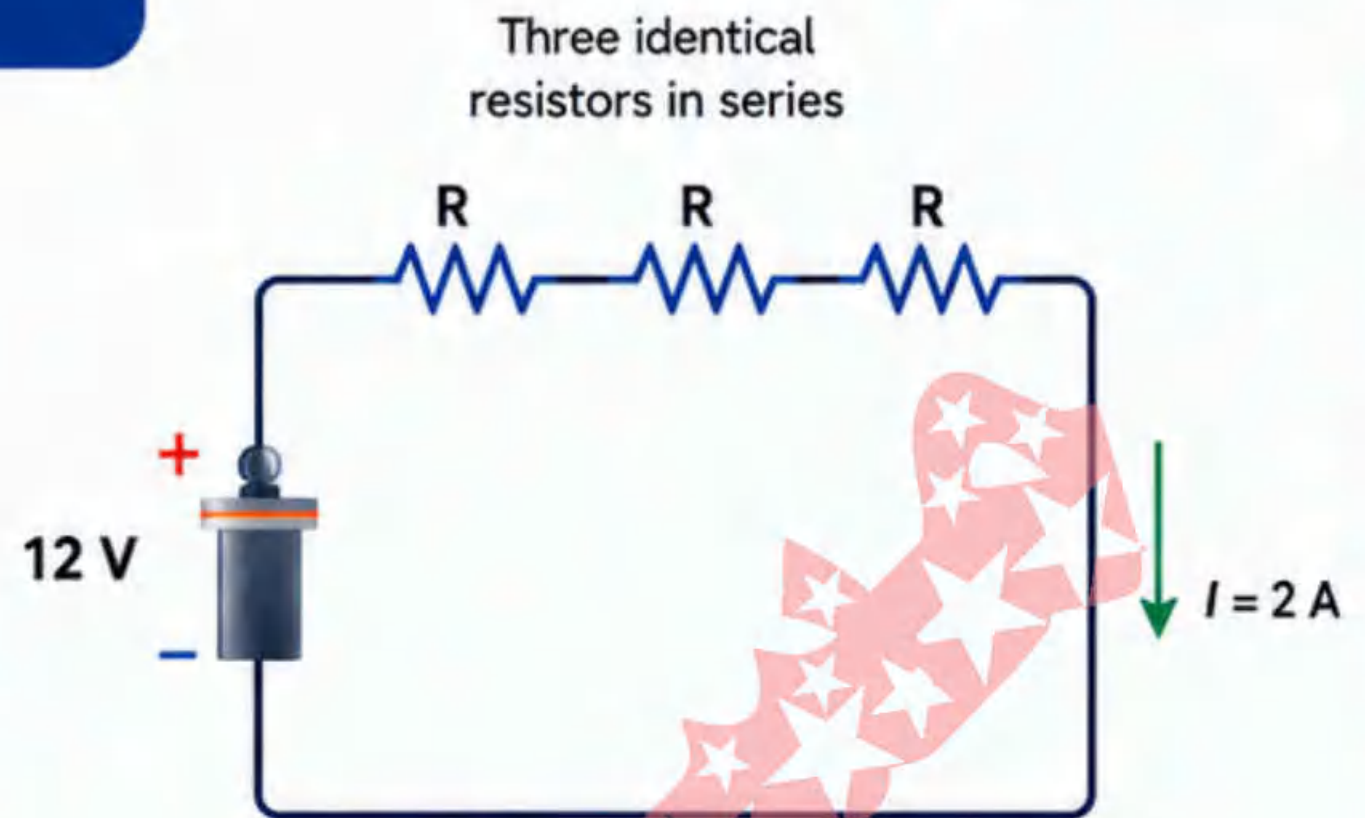
- 1 The equivalent resistance of the circuit:

$$R_{eq} = \frac{V}{I} = \frac{12}{2} = 6 \Omega$$

- 2 For resistors in series: $R_{eq} = N \times R$
where $N = 3$ resistors.

- 3 Resistance of one resistor:

$$R = \frac{R_{eq}}{N} = \frac{6}{3} = 2 \Omega$$



Key Relations

- $R_{eq} = \frac{V}{I}$
- For series: $R_{eq} = N \times R$



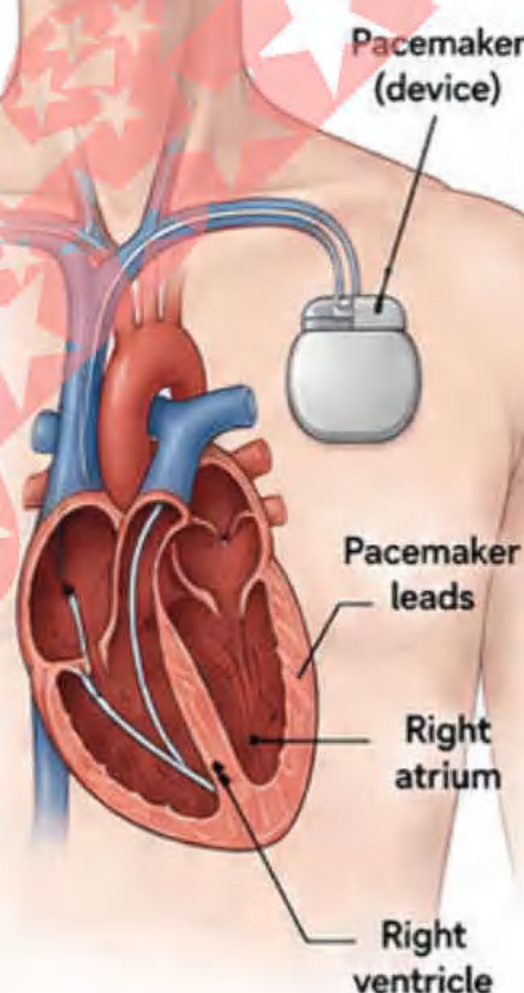
2 INTEGRATION WITH MEDICINE

The Pacemaker

A pacemaker is a practical application that combines concepts of electrical circuits with the function of organs.

The device is implanted under the patient's skin. It consists of a battery, a smart chip made of tiny electronic circuits to control the device, and wires connected directly to the heart muscle.

If the natural heartbeat becomes delayed, it sends tiny electrical pulses that stimulate the muscle to contract regularly, ensuring efficient pumping of blood.

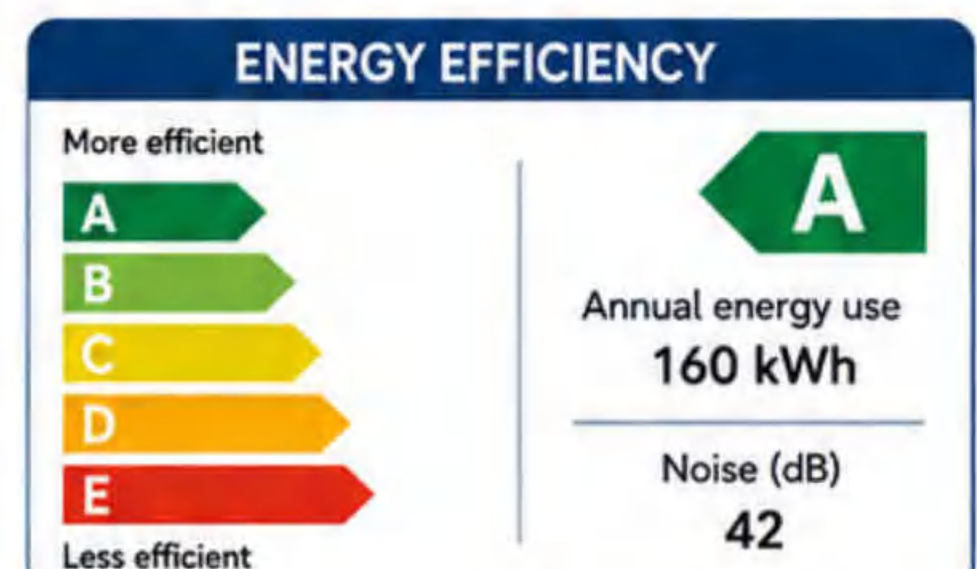


3 ENERGY EFFICIENCY LABEL

The energy efficiency label shows the device's monthly electrical energy consumption and its efficiency level.

This helps the consumer choose the product that consumes less energy and avoid low-efficiency products.

The green arrow marked "A" indicates the highest efficiency and the lowest energy consumption.



Many electrical devices also show important specifications such as the required potential difference and the electric power of the device.



Potential
Difference (V)



Power
(P)



Rated
Power

Electric Power and Electrical Energy 6/7



1 WHAT DOES 9 W MEAN?



Electric power (P) is the rate at which a device consumes electrical energy.

It is the amount of electrical energy (E) consumed in one second.

W Power is measured in watt (W).

J Energy is measured in joule (J).



1 W = 1 J/s. Therefore, a 9 W LED lamp consumes 9 J of electrical energy in one second.



2 FORMULAS

Electric Power (P)

Power is the rate of consuming electrical energy.

$$P = \frac{E}{t}$$

Electrical Energy (E)

Energy equals power multiplied by the time of use.

$$E = P \times t$$

Where:

P: power (W)

E: electrical energy (J)

t: time (s)



3 PRACTICAL UNIT OF ENERGY

In everyday life, the joule (J) is a very small amount of electrical energy. That is why we use the larger unit kilowatt-hour (kWh).

$$1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$$



1 kilowatt (kW) = 1000 watt (W)



1 hour (h) = 3600 second (s)



1 kWh is the energy consumed by a 1000 W device operating for one hour.



HOME METER



This meter measures the total electrical energy used in your home in kilowatt-hours. The utility company uses this reading to calculate your electricity bill.



GOOD TO KNOW

- Devices with higher power ratings consume more energy in the same amount of time.
- Saving electricity helps reduce costs and protects our environment.



4 HOW TO CALCULATE THE COST OF ELECTRICAL ENERGY USED BY A DEVICE

1



Find the power of the device in kilowatts.

$$\text{Power (kW)} = \frac{\text{Power (W)}}{1000}$$

2



Find the number of operating hours.

Operating hours (h)

3



Energy consumed (in kilowatt-hour).

$$\text{Energy (kWh)} = \text{Power (kW)} \times \text{Operating hours (h)}$$

4



Cost of consumption.

$$\text{Cost} = \text{Energy (kWh)} \times \text{Price of one kilowatt-hour}$$

Saving Energy at Home

7/7



1 WORKED COMPARISON: CFL vs LED

A 20 W compact fluorescent lamp (CFL) and a 12 W LED lamp give approximately the same light intensity and each works 12 hours daily. Assume the average price of 1 kWh is 1.55 Egyptian pounds.

Monthly operating time: $t = 30 \times 12 = 360 \text{ h}$

CFL Lamp (20 W)

- $P = \frac{20}{1000} = 0.02 \text{ kW}$
- $E = P \times t = 0.02 \times 360 = 7.2 \text{ kWh}$
- Monthly cost = $1.55 \times 7.2 = 11.16 \approx 11.2 \text{ Egyptian pounds}$

LED Lamp (12 W)

- $P = \frac{12}{1000} = 0.012 \text{ kW}$
- $E = P \times t = 0.012 \times 360 = 4.32 \text{ kWh}$
- Monthly cost = $1.55 \times 4.32 = 6.696 \approx 6.7 \text{ Egyptian pounds}$



Conclusion:

LED lamps consume less energy than CFL lamps for the same period of operation, so they have higher efficiency and reduce electrical energy use and cost, helping conserve financial and environmental resources.



2 EXAMPLES OF HOUSEHOLD DEVICES AND THEIR ELECTRIC POWER

Device	Power (W)	Device	Power (W)
Electric heater	1 – 2 kW	Laptop	50 W
Clothes iron	1 – 2.5 kW	Fan	50 – 100 W
Air conditioner	1.5 – 2.5 kW	Television	100 W



Note: Air conditioners and heating appliances are among the highest electrical-energy consumers.



3 CAUSE AND EFFECT



CAUSE

Increasing the operating time of an electrical device.



EFFECT

Increase in the electrical energy consumed and therefore a higher consumption cost.



4 SAFETY PRECAUTIONS



- Avoid overloading by connecting several high-power devices to one socket.
- Make sure wires are well insulated.
- Make sure hands, wires, and components are dry before closing the circuit because tap water conducts electricity.
- Disconnect the electric source completely before modifying any part of the circuit or replacing a component.
- Do not use household electrical sources in the experiments presented in this unit.

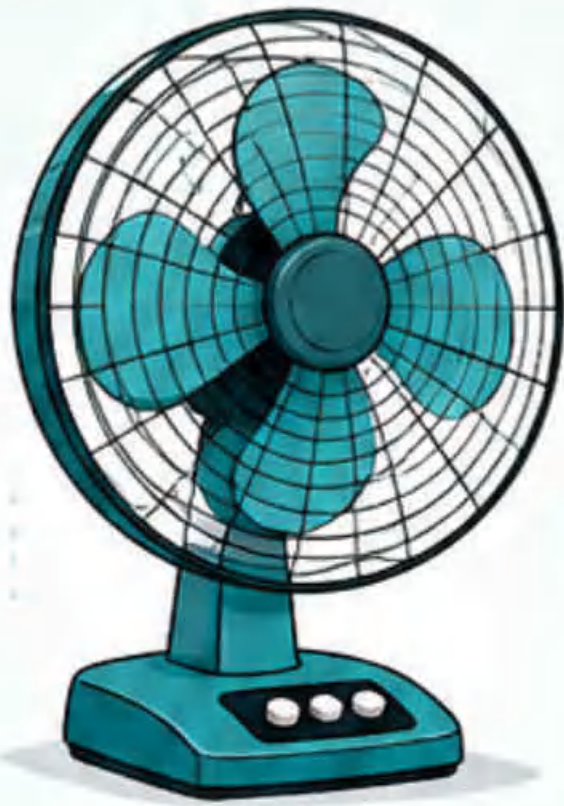




Lesson 3: Electric and Magnetic Forces



Lesson Overview

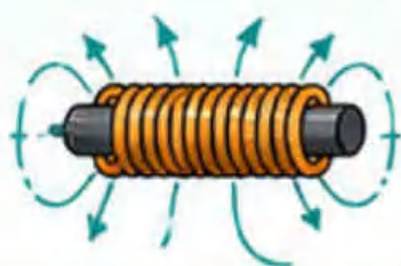


1 ENGAGING INTRO

The electric fan shown here helps you answer these questions:

- How does a fan work?
- How does the fan motor convert electrical energy into mechanical energy?
- How can the speed of the fan motor be controlled?

2 KEY TERMS



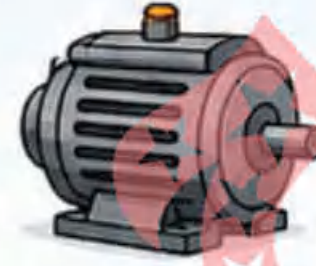
Electromagnet



Permanent Magnet



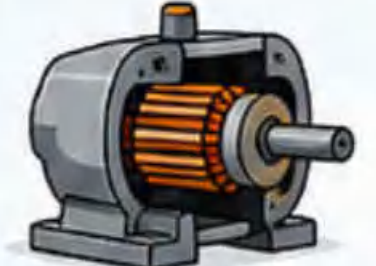
Magnetic Force



Electric Motor



Torque



Electric Generator

3 LEARNING OBJECTIVES

- 1 Infer the magnetic effect of electric current.
- 2 Explain the structure, working principle, and some applications of the electromagnet.
- 3 Infer the factors that affect the strength of an electromagnet.
- 4 Explain the magnetic force acting on a wire carrying electric current and some applications of it.
- 5 Describe the structure and working principle of the electric motor.
- 6 Infer the factors that affect the motor's turning torque and some applications of it.
- 7 Describe the structure and working principle of the electric generator.
- 8 Infer the factors that affect the electromotive force produced by the electric generator.

4 SKILLS, VALUES, AND CROSSCUTTING CONCEPTS



SKILLS

Practical work – Modeling – Communication – Critical thinking – Evaluating sources and reliability



VALUES

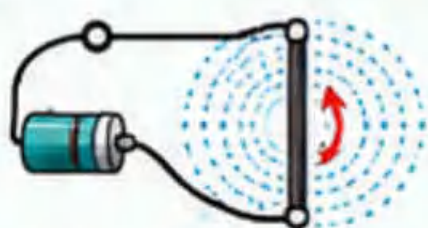
Cooperation – Self-protection



ISSUES AND CONCEPTS

Protecting environmental resources – Using clean energy sources
Cause and Effect – Structure and Function

5 LESSON PATH



Magnetic effect of current



Electromagnet



Electric motor



Electric generator

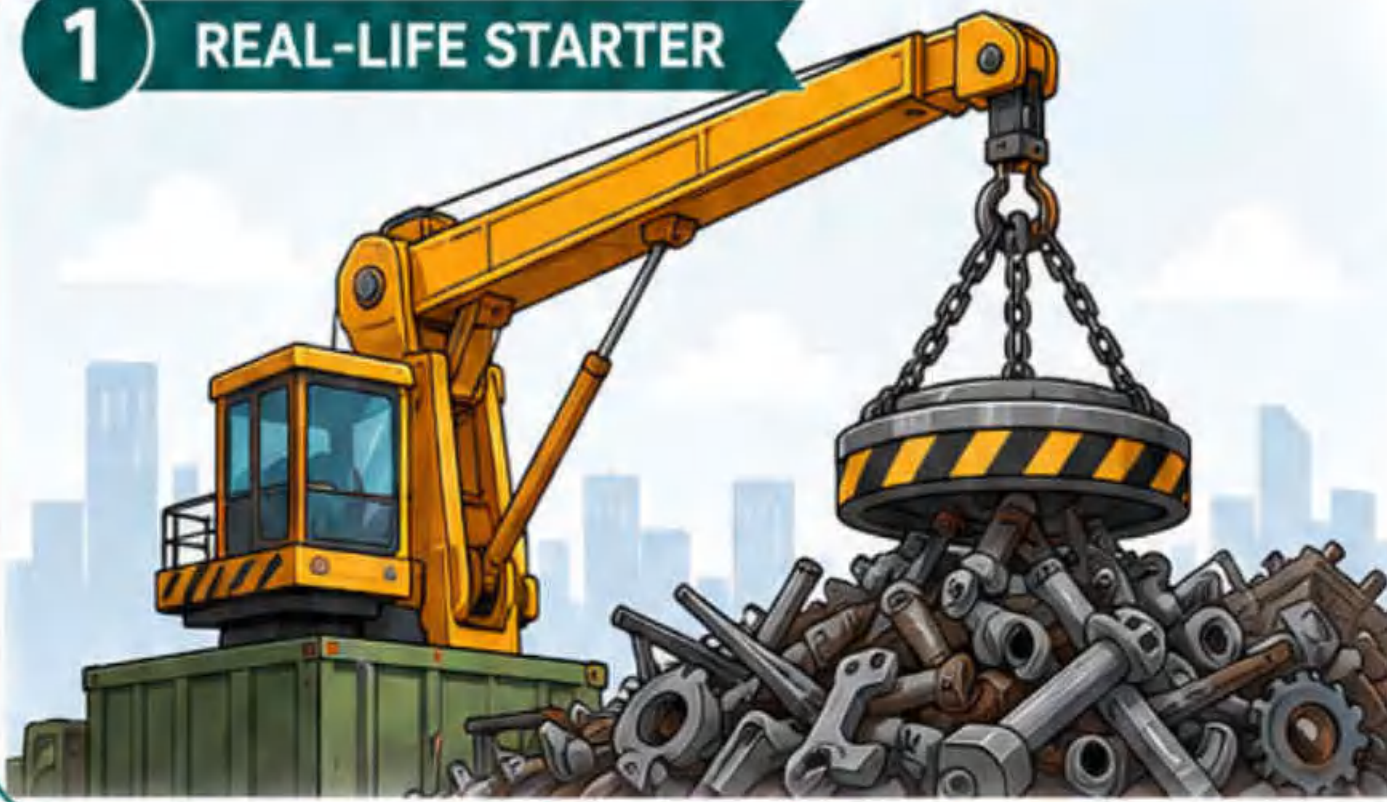


Magnetic Effect of Electric Current



From Oersted's observation to the magnetic field

1 REAL-LIFE STARTER



In scrap yards, a machine like this is used to move heavy iron pieces from one place to another.

How does it work, and how can its strength be controlled?

2 KEY IDEA



Hans Oersted discovered that when electric current passes through a wire, a magnetic field is produced around the wire. This causes the compass needle to deflect from its original direction. This phenomenon is called the **magnetic effect of electric current**.

★ This discovery became the basis of many devices that depend on the relationship between electric and magnetic forces, such as the electromagnet, the electric motor, and the electric generator.

3 ACTIVITY 1 – OBSERVE AND INFER

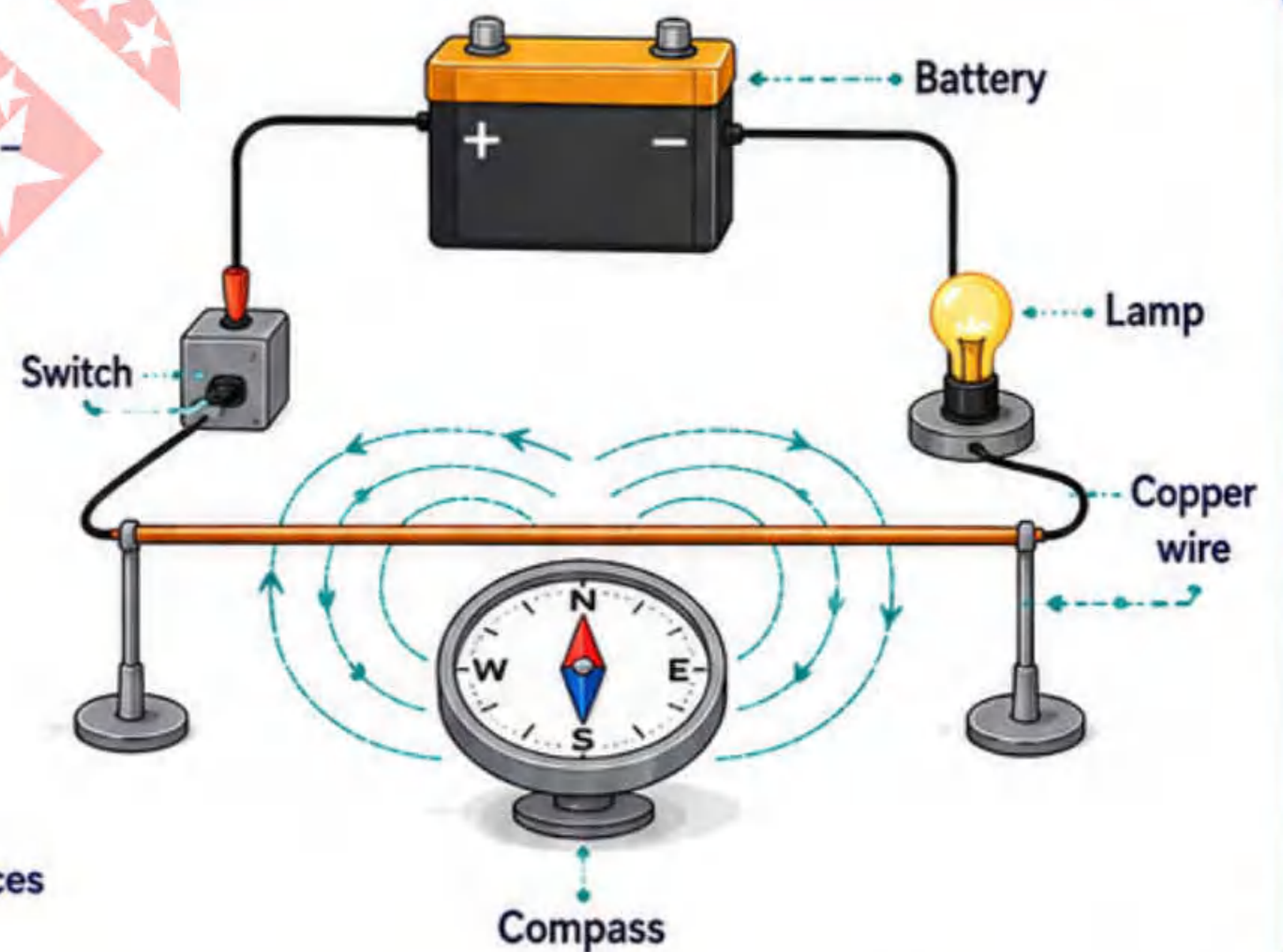
TOOLS: Battery – Insulated copper wire – Compass – Small electric lamp – Switch

STEPS:

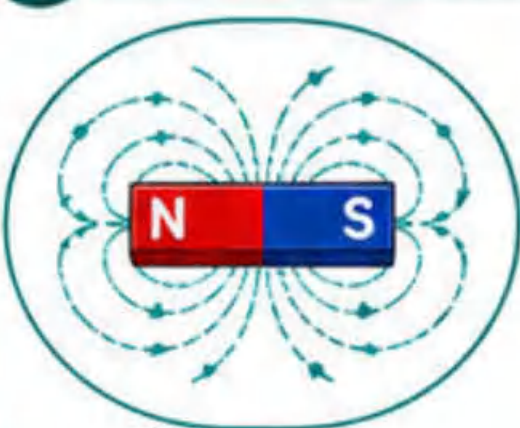
- 1 Place the compass on a horizontal table and wait until it becomes steady.
- 2 Connect the electric circuit as shown.
- 3 Place the wire above the compass and parallel to its axis.
- 4 Close the electric circuit.

OBSERVATION: The compass needle deflects.

CONCLUSION: A wire carrying electric current produces a magnetic field around it.



4 BUILD YOUR KNOWLEDGE



Magnetic field

The region around a magnet where the effects of its magnetic force appear.



Compass needle

A small freely moving magnet that naturally points north under the effect of Earth's magnetic field.



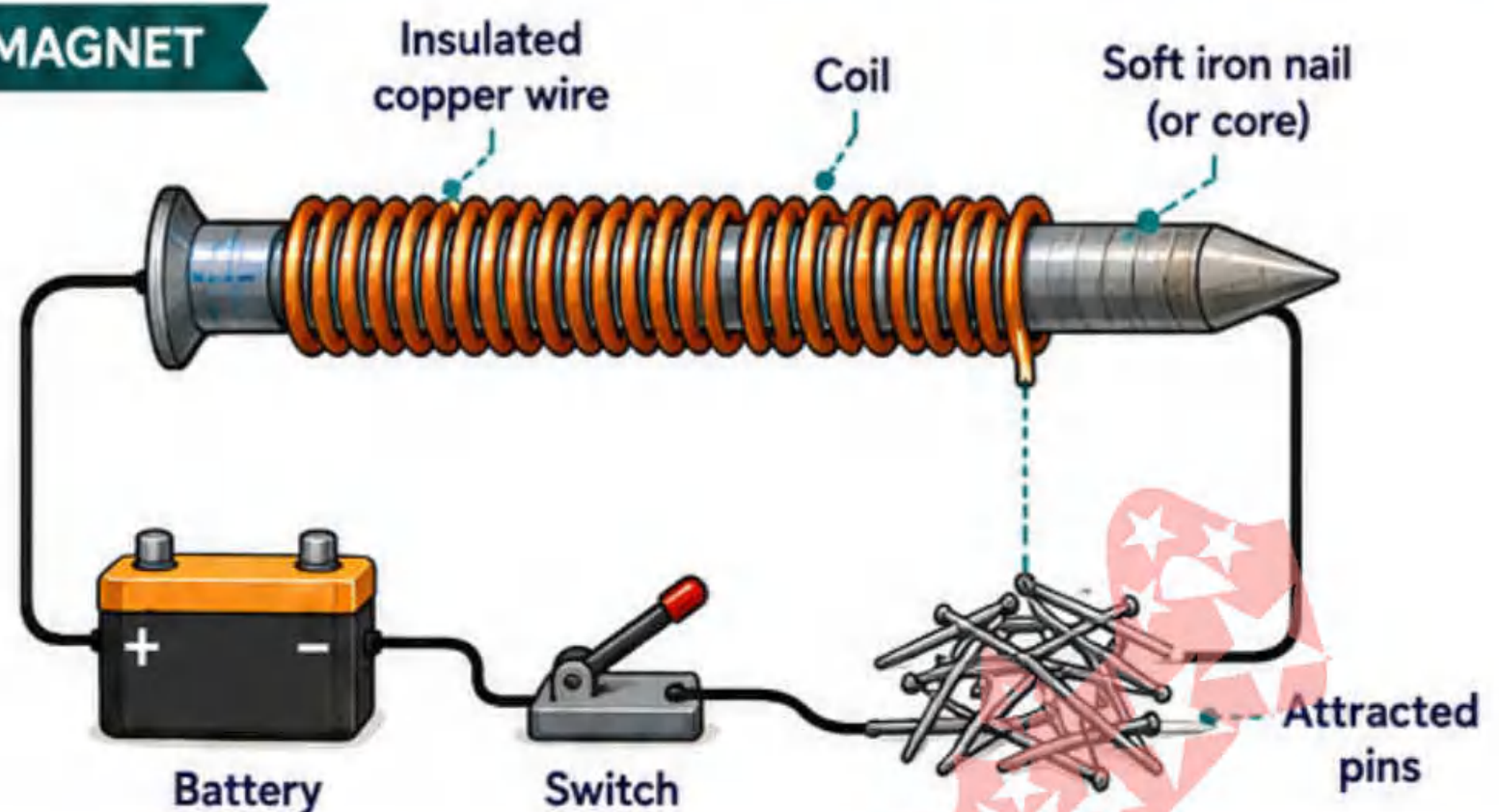
Electromagnet



A temporary magnet made by electric current

1 STRUCTURE OF AN ELECTROMAGNET

An electromagnet consists of an insulated copper wire wound around a soft iron core. When electric current passes through the coil, a magnetic field is produced around it and the iron core becomes magnetized.

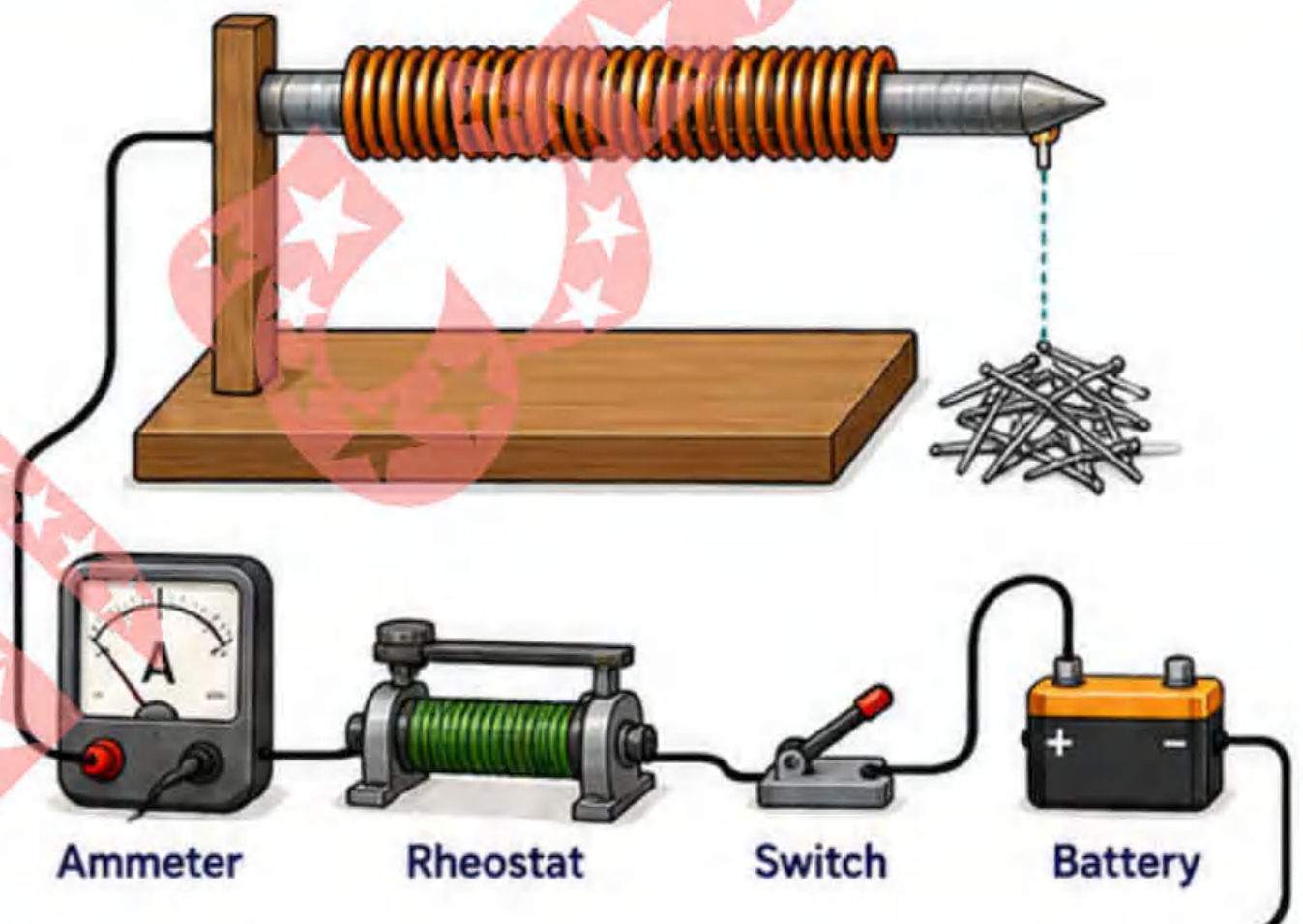


2 ACTIVITY 2 – TRY AND INFER

TOOLS: Switch – Battery – Long insulated copper wire – Long soft-iron nail – Ammeter – Rheostat – Iron pins – Wooden stand

STEPS:

- 1 Wind the copper wire neatly as a coil around the soft-iron nail to make an electromagnet.
- 2 Fix the nail and the coil in the wooden stand.
- 3 Connect the two ends of the coil to the circuit shown.
- 4 Place the metal pins at a suitable distance, about 1 cm directly below the nail.
- 5 Use the switch to close the circuit for a few minutes.
- 6 Open the circuit again.



OBSERVATION:

- When current passes, the nail attracts the pins.
- When the circuit is opened, the pins fall.

CONCLUSION:

- The electromagnet works only while current passes through the coil.

3 WHAT DO WE LEARN?



- Current in the coil produces a magnetic field.
- The soft iron nail becomes a magnet and attracts the pins.
- The electromagnet is a temporary magnet because it can be turned on and off by allowing or stopping the current.



This explains why electromagnets are useful for moving iron scrap from one place to another.

4 RESEARCH NOTE



Search for the role of the electromagnet in separating metal waste before recycling, and how this helps save energy needed for production.





How to Increase Electromagnet Strength



Control variables and infer the important factors

1 ACTIVITY 3 – CONTROL THE VARIABLES

- 1 How can you tell how strong an electromagnet is?
- 2 Suggest some factors that may increase its strength.
- 3 Change one factor only, keep the other factors constant, and observe what happens to the strength of the electromagnet.

★ Try another factor and compare the result.



Independent variable:
the factor you change



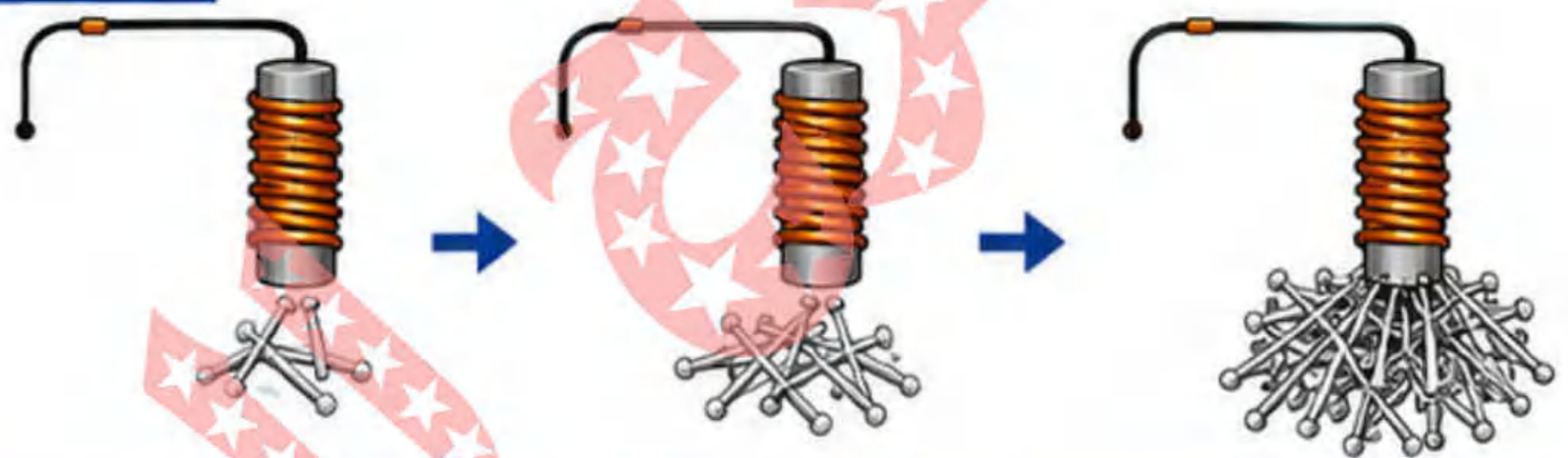
Dependent variable:
electromagnet strength



Controlled factors:
the other conditions
kept constant

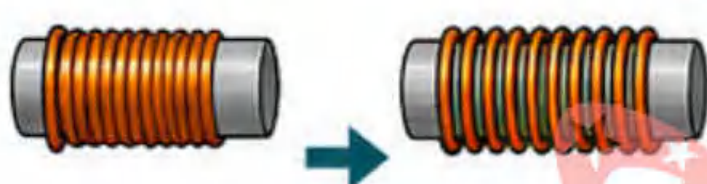
2 HOW DO WE MEASURE STRENGTH?

The number of pins attracted by the electromagnet can be used as an indicator of its strength. The more pins it attracts, the stronger its magnetic force.



3 FACTORS THAT INCREASE THE STRENGTH OF AN ELECTROMAGNET

More turns of the coil



More turns create a stronger magnetic field.

Greater current through the coil

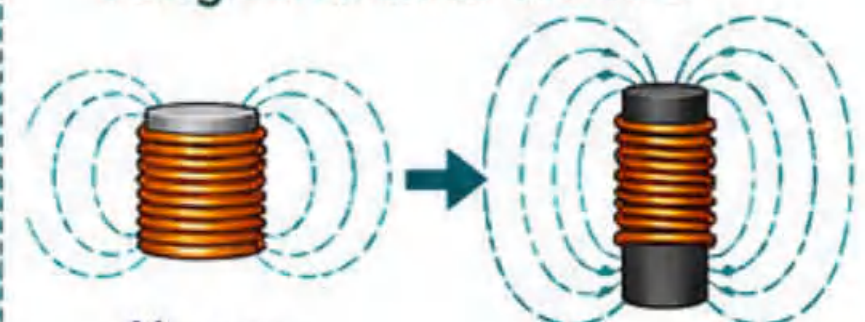


Low current

High current

More current produces a stronger magnetic field.

Using soft iron as the core



Air core

Soft iron core

Soft iron becomes strongly magnetized and boosts strength.



So, the strength of an electromagnet increases with more coil turns, stronger current, and a soft-iron core.

4A CHECK YOUR UNDERSTANDING

Compare the permanent magnet and the electromagnet:

Similarity



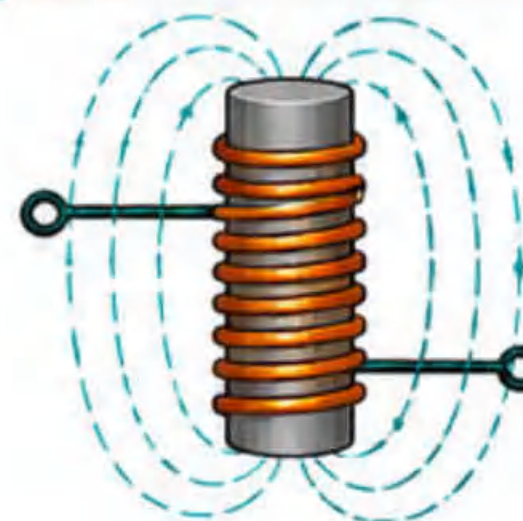
Both produce magnetic force and can attract magnetic materials.

Difference



A permanent magnet keeps its magnetism, while an electromagnet is temporary and depends on electric current.

4B STRUCTURE AND FUNCTION

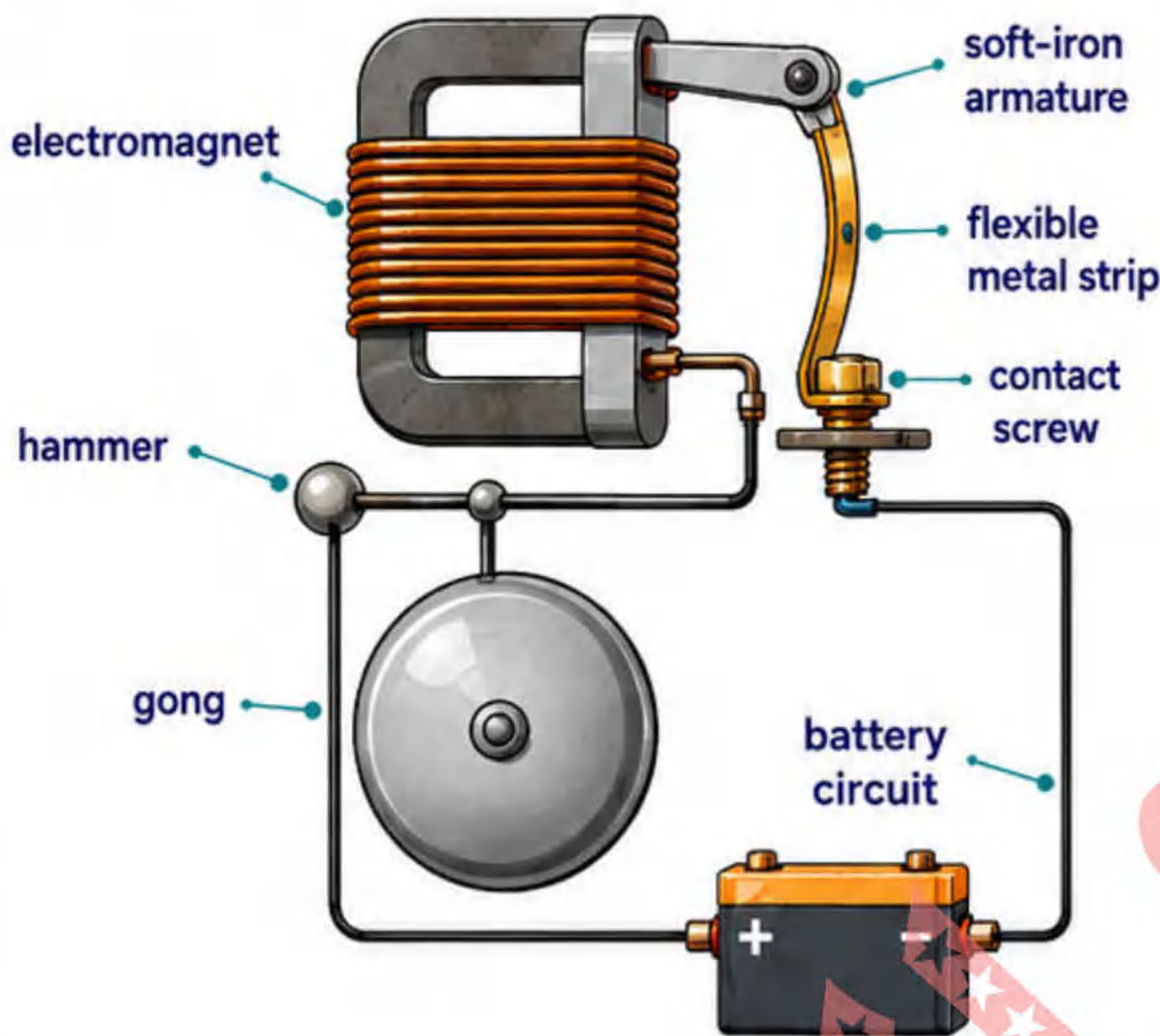


The core of the electromagnet is made of soft iron because it gains and loses magnetism easily. This makes the electromagnet a temporary magnet.

Electric Bell and Magnetic Force on a Current-Carrying Wire

From the electromagnet to the moving conductor

1 TECHNOLOGY APPLICATION – ELECTRIC BELL



HOW IT WORKS

- 1 When the bell button is pressed, the circuit is closed.
- 2 The iron core of the electromagnet becomes magnetized and attracts the metal strip.
- 3 The hammer strikes the gong and produces a sound.
- 4 At the same moment, the circuit opens because the strip moves away from the contact screw.
- 5 The electromagnet loses its magnetism, so the strip returns to its original position and closes the circuit again.
- 6 The process repeats quickly, producing a continuous ringing sound.

2 ACTIVITY 4 – TRY AND INFER

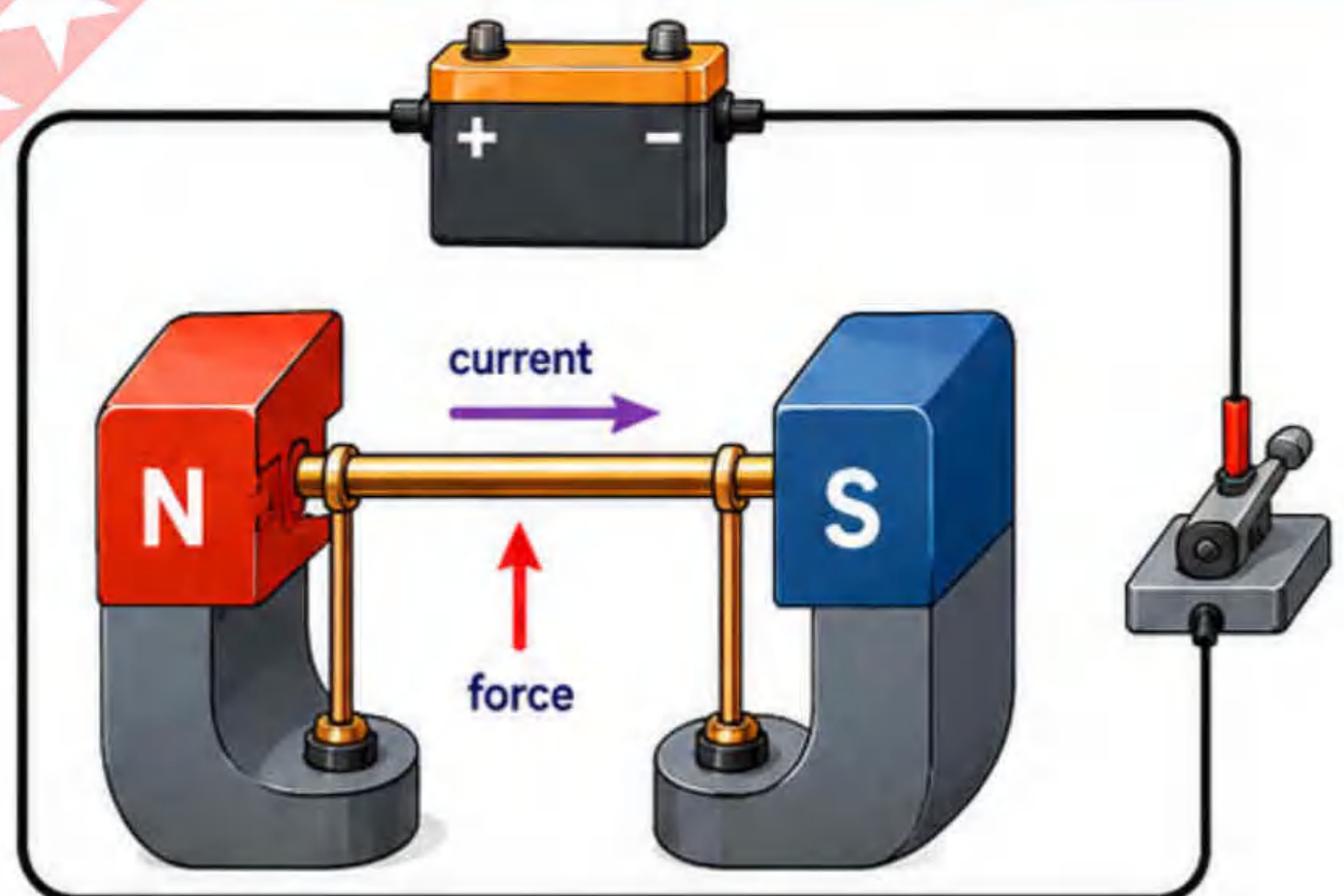
TOOLS: Strong U-shaped permanent magnet – Cylindrical metal rod – Two copper rods – Battery – Switch – Connecting wires

STEPS:

- 1 Arrange the tools to form the device shown.
- 2 Connect the two ends of the device to the battery and the switch to form an electric circuit.
- 3 Close the electric circuit.

OBSERVATION: The straight conductor moves.

CONCLUSION: If a straight conductor is placed perpendicular to a magnetic field and electric current passes through it, the conductor is acted upon by a magnetic force in a certain direction. This force may move it.

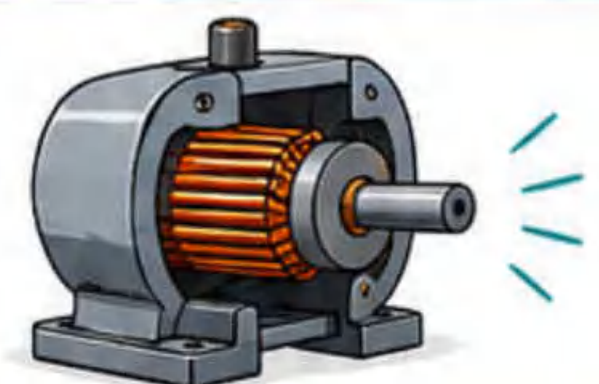


3 IMPORTANT RESULT



A current-carrying conductor can move when it is placed in a magnetic field.

This idea led to the invention of the electric motor.





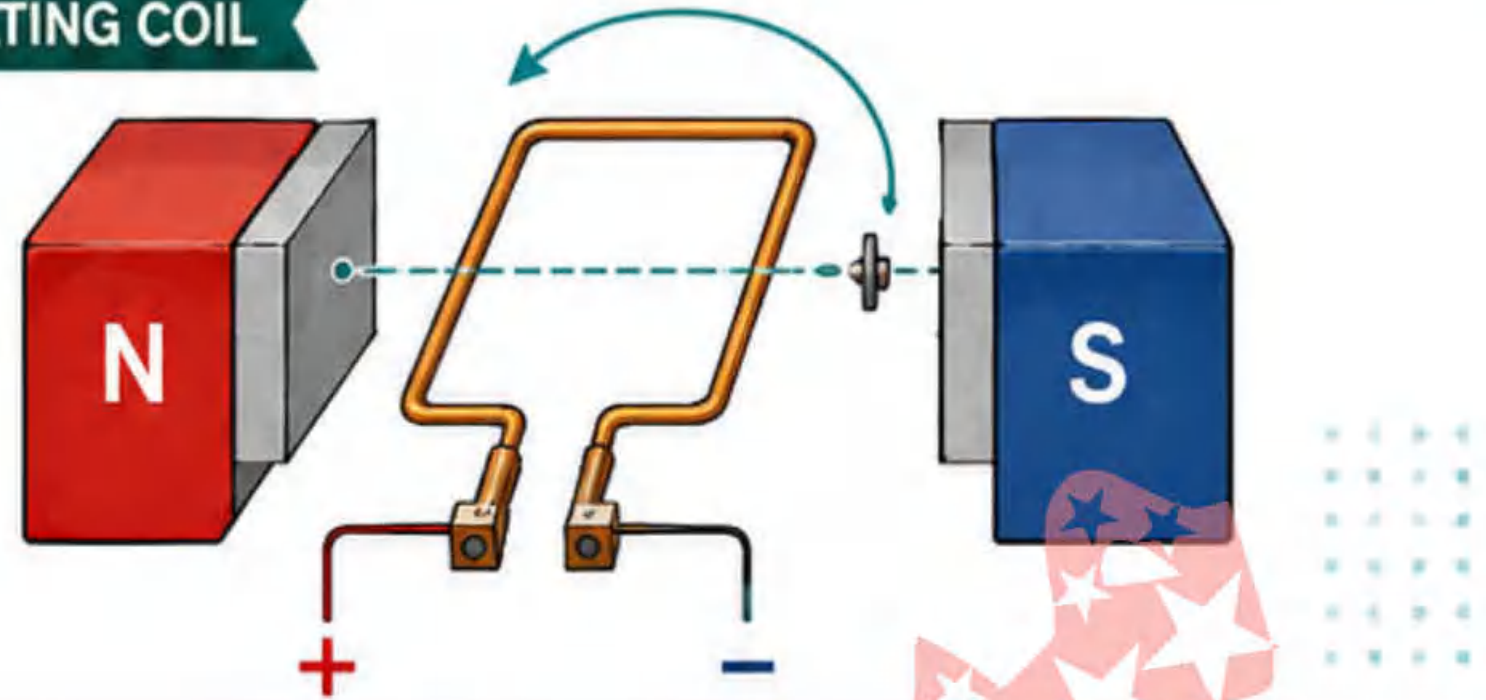
Simple Electric Motor



How a rotating coil turns electrical energy into motion

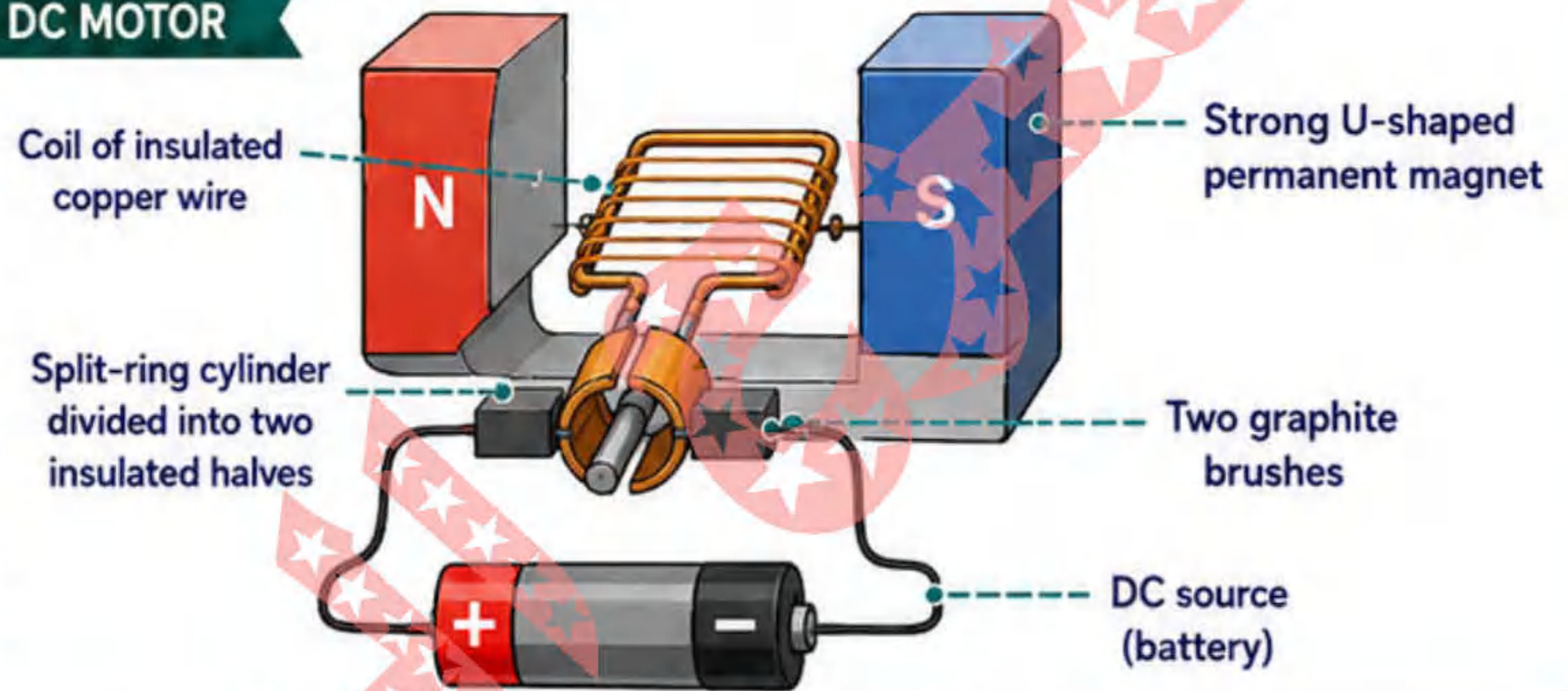
1 FROM A MOVING WIRE TO A ROTATING COIL

If a coil is placed between the poles of a magnet instead of a single wire, and electric current passes through the coil, the coil moves. This idea led to the invention of the electric motor.



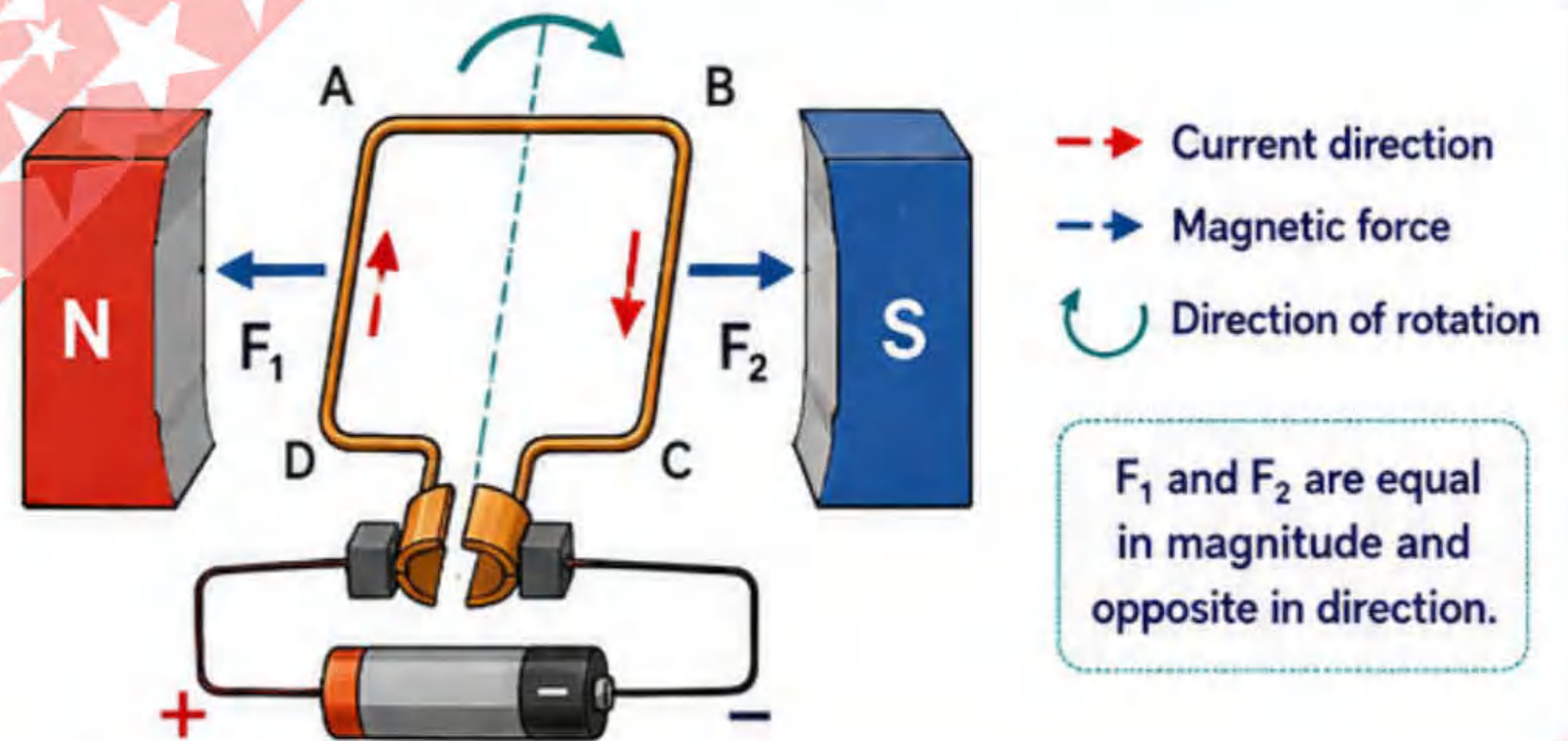
2 CONSTRUCTION OF A DC MOTOR

A simple DC motor consists of a coil that can rotate freely between the poles of a strong permanent magnet.



3 WORKING PRINCIPLE

When electric current passes through the motor coil, magnetic forces act on the two long sides of the coil. The two forces are equal in magnitude, opposite in direction, and act along different lines. This produces a turning effect called torque, which rotates the coil.



4A TORQUE



Torque is the turning effect produced by a pair of equal and opposite forces acting along different lines.

4B EVERYDAY EXAMPLE



A steering wheel turns because two forces acting on its sides produce torque.



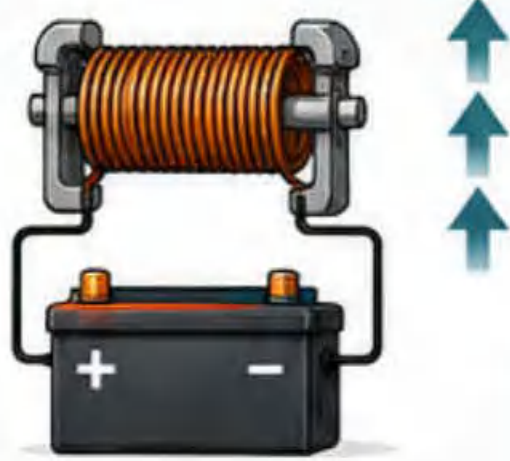
Controlling Motor Rotation and Speed



Factors affecting torque and everyday applications

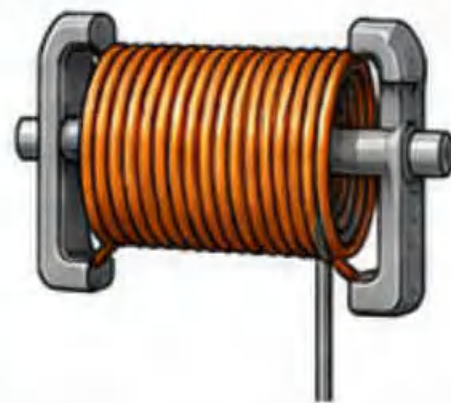
1 WHAT INCREASES MOTOR TORQUE?

Higher electric current in the coil



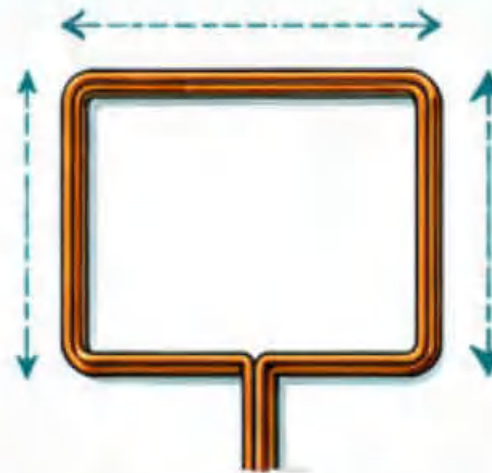
More current produces a stronger magnetic force on the coil.

More turns of the coil



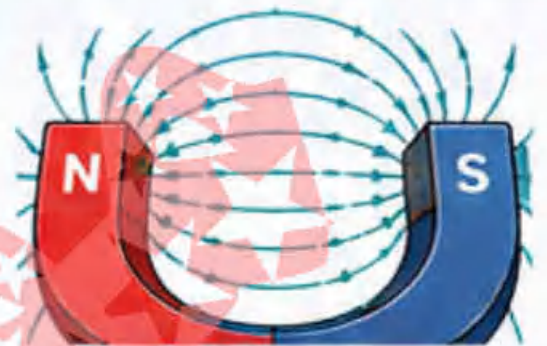
More turns mean more wire in the field, so the magnetic force increases.

Larger area of the coil face



A larger area interacts with more magnetic field, increasing torque.

Stronger magnetic field, which can be increased by using stronger magnets or a larger number of magnets



A stronger field produces a greater force on the coil.



Cause:

Increasing the number of magnets in the motor.



Effect:

The turning torque of the motor increases.

2 APPLICATIONS OF THE ELECTRIC MOTOR

The electric motor converts electrical energy into kinetic energy.



Mixers



Fans



Electric washing machines



Electric cars



Metro

3 THINK CRITICALLY



A motor rotates in the direction shown.

Suggest two ways by which the direction of rotation of the coil can be reversed.

4 PRACTICAL APPLICATION – ELECTRIC DRILL AND SCREWDRIVER



LOW SPEED

When loosening or tightening screws, the motor is adjusted to a low speed to ensure accuracy and to avoid damaging the screw head.



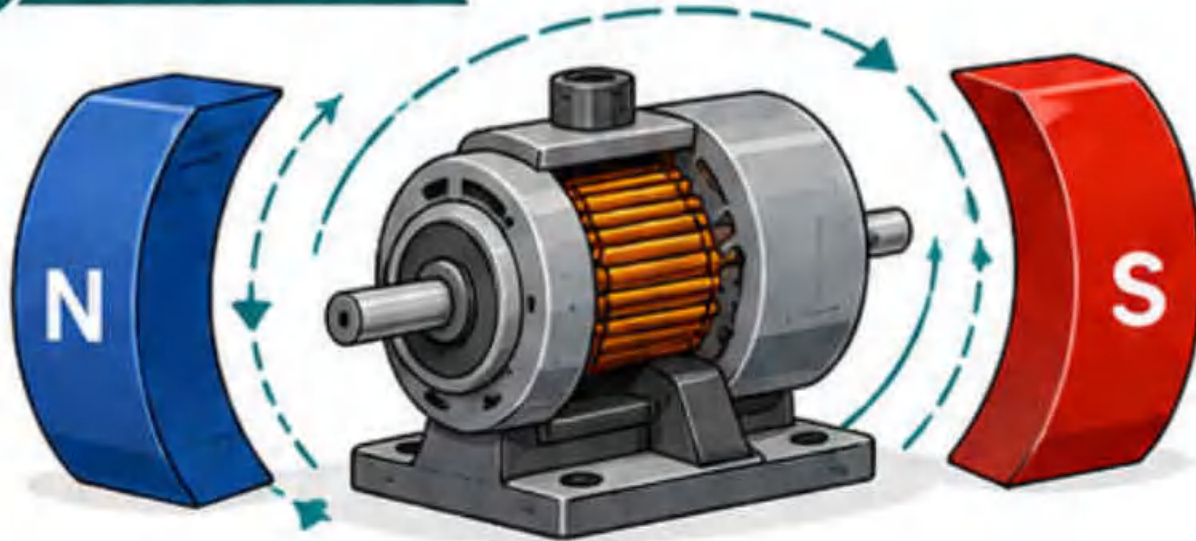
VERY HIGH SPEED

When drilling walls, the motor is adjusted to a very high speed to provide the kinetic energy needed to penetrate the solid surface.

Electric Generator

When a motor works in reverse

1 MAIN IDEA



The electric motor is used to produce kinetic energy. But if we rotate the shaft of the motor by hand, the device works in reverse and produces electrical energy. This is the scientific principle of the electric generator.

2 ACTIVITY 5 – TRY AND INFER

TOOLS:



Small DC motor
(such as a toy motor)



LED lamp or
small lamp



Connecting
wires



Small fan or
hand crank

STEPS:

- 1 Use wires to connect the two terminals of the motor coil to the LED lamp or the small lamp instead of the battery.
- 2 Fix the small fan firmly to the rotating shaft of the motor coil.
- 3 Hold the motor firmly, then rotate the fan with your fingers.
- 4 Try rotating the fan slowly, then quickly, and observe the brightness of the lamp.

OBSERVATION:



The lamp lights when the shaft is, and its brightness increases when the rotation becomes faster.

CONCLUSION:



When the motor coil is rotated between the poles of the magnet, the device generates an electromotive force and becomes an electric generator.

NOTE



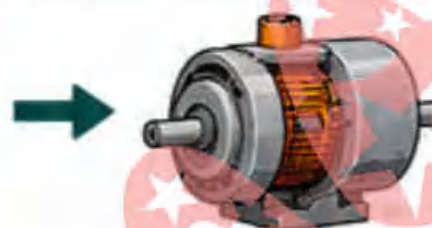
An LED lights only when current passes through it in one direction. If it does not light, reverse its connection to the device.

3 ENERGY CONVERSION

MOTOR (normal operation)



Electrical energy



Mechanical (kinetic) energy



GENERATOR (reverse operation)



Mechanical (kinetic) energy



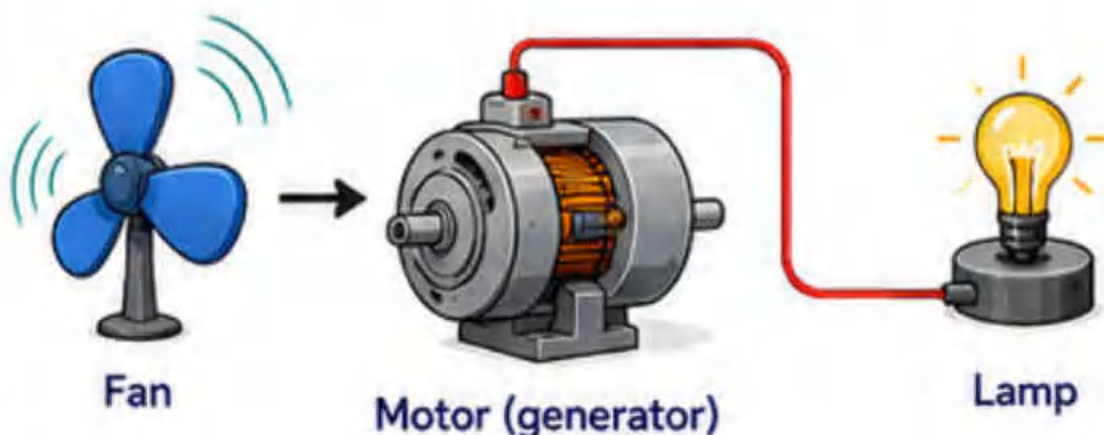
Electrical energy



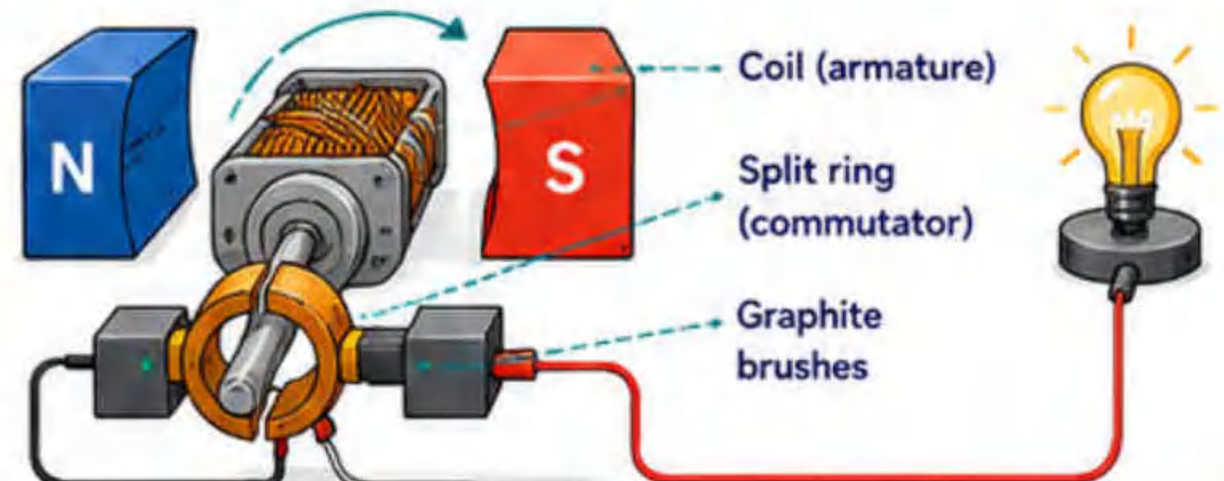
The motor converts electrical energy into mechanical (kinetic) energy. When operated in reverse by rotating its coil between the magnet poles, the device converts mechanical energy into electrical energy.

4 GENERATOR DIAGRAM

A small motor used as a generator



Direct-current generator with brushes



How the Generator Works and Its Uses

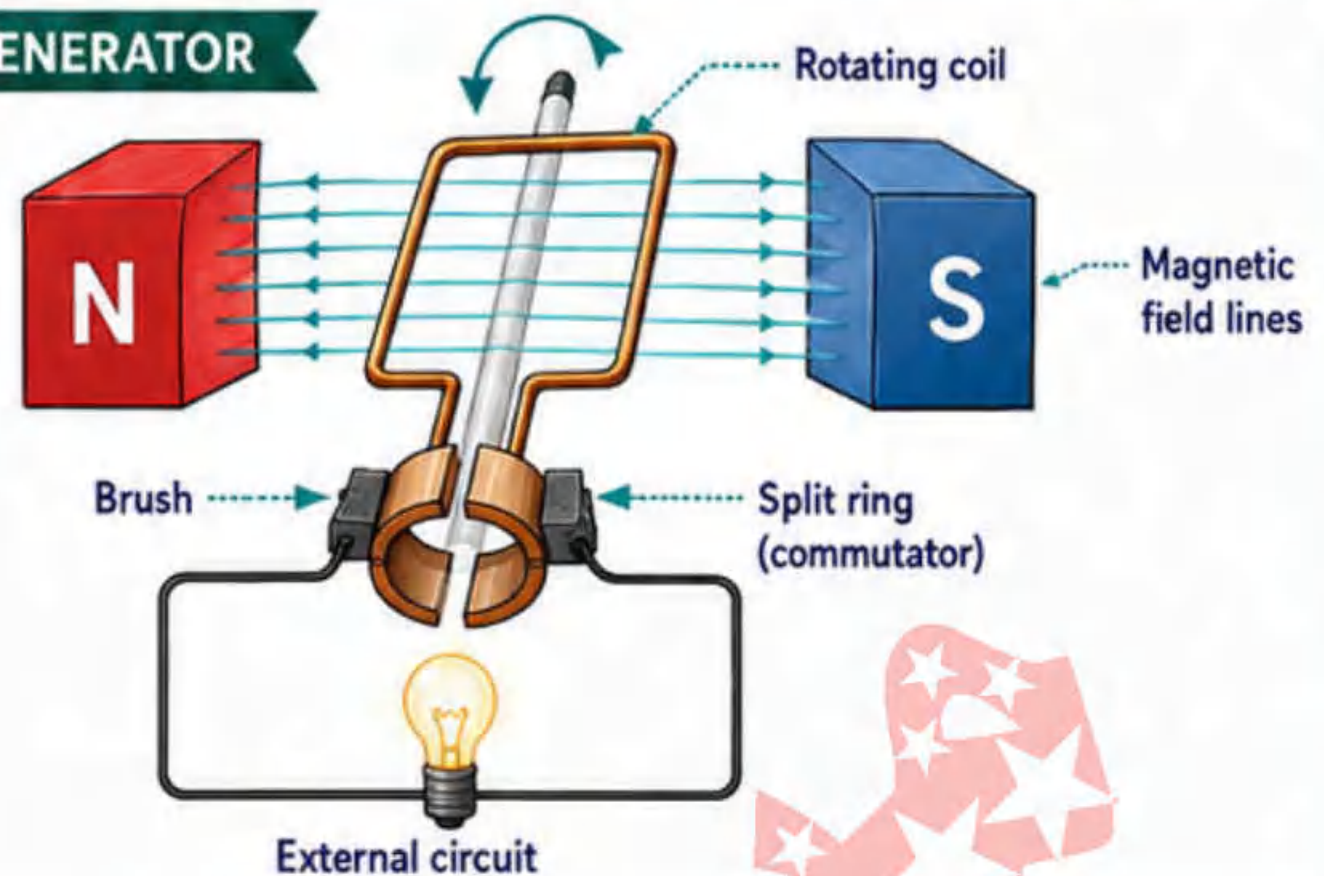
From rotating coils to useful electrical power

1 WORKING PRINCIPLE OF THE ELECTRIC GENERATOR

The generator coil rotates between the poles of the magnet by the effect of a source of kinetic energy. As the coil cuts the magnetic field lines, an electromotive force is generated, causing electric current to pass into the external circuit.

★ MINI DEFINITION

Magnetic field lines are imaginary lines that represent the direction and strength of the magnetic field.



2 USES OF THE ELECTRIC GENERATOR

The electric generator converts kinetic energy into electrical energy.

A POWER STATIONS



- Large turbines rotate the coils of huge generators to produce the electricity needed for cities and factories.
- These turbines obtain the energy needed for rotation from different energy sources such as waterfalls, steam, or wind.
- A generator connected to a split ring, as shown in the direct-current generator, produces current in one direction only.
- In power stations, a different type of generator produces alternating current, which is the electric current used in homes.
- Alternating current can be transmitted from power stations to places of use with low loss of electrical energy, and it can also be converted into direct current similar to the current obtained from batteries.

B EMERGENCY GENERATORS



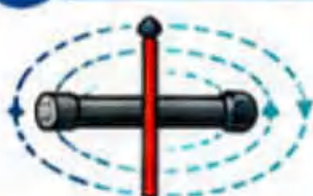
- Emergency generators are used in homes, hospitals, and factories when the electric current is cut off.

3 EVERYDAY APPLICATION – BICYCLE DYNAMO



- The traditional type is mounted against one side of the bicycle wheel.
- When the wheel moves, the dynamo shaft transfers the motion by friction to the generator coil.
- The device converts kinetic energy into electrical energy to light the lamps without batteries.
- The electromotive force produced by the generator increases when the speed of rotating the coil increases, so the bicycle lamp glows more brightly as the wheel rotates faster.

4 QUICK REVIEW



Current in a wire
→ magnetic field



Electric motor:
electrical energy
→ kinetic energy



Electric generator:
kinetic energy
→ electrical energy

5 LESSON COMPLETE



You have completed Lesson 3: Electric and Magnetic Forces.



موقع الدكتور محمد رزق التعليمي



امسح الباركود بالموبيل لتثبيت
التطبيق وتحميل كل الملازم مجاناً وبسرعة



حمل التطبيق الآن



كورسات ونتائج امتحانات



ملازم ثانوي



ملازم اعدادي



ملازم ابتدائي



موقع الدكتور محمد رزق
Dr. Mo. RAZK



D.M.RAZK

موقع الدكتور محمد رزق معلم الكيمياء التعليمي